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The Ancestry of the Camel.

By R. LYDEKKER.

CAMELS—or rather some of their immediate ancestors—have been accorded a privilege commonly said to be reserved among ourselves for the fair sex; in other words, metaphorically speaking, they have been permitted to change their minds. For there can be little doubt that when these animals originally started on the road of getting up in the world—that is to say, on a course of specialised development—they intended to become good and typical ungulates like their distant cousins the true ruminants; and, for a time at least, the ancestral camels appear to have had their toes encased in good serviceable hoofs of horn. For some reason or other, of which we are at present quite ignorant, they appear to have considered that this plan was a mistake, and they accordingly struck out a line of their own, and underwent a kind of retrogade evolution, with the result that in their modern descendants their feet, instead of being covered with hoofs, are fitted with large spreading and elastic cushions, in which the two toes are to a great extent buried, bearing small nails on their upper surface only. The reason for this remarkable modification is not very easy to see. It is true, indeed, that the cushion-like feet of the typical camels of the Old World (from which the group derives its scientific title of *Tylopoda*) are admirably adapted for walking on the yielding sands of the deserts of Central Asia and Africa. But, on the other hand, such deserts are likewise the home of many hoofed ruminants, such as the North African addax antelope and the Mongolian gazella. Again, the wild representatives of the South American llamas (which, in a collective sense, also come under the denomination of camels) are associated in their native wilds with the guemal deer, which, like the rest of its kind, has horny hoofs of the normal type. Moreover, the wild Mongolian ponies inhabit the same tracts as the half-wild camels of the same country.

All that can be said, therefore, is that we must take facts as we find them; and that, for some reason with which we are unacquainted, the members of the camel tribe have developed a type of foot quite unlike that of any other ungulates, and well adapted, although by no means essential, to the countries where these animals are found. Away from such tracts, the feet of camels are, however, not infrequently a source of inconvenience, or it may be absolute helplessness, to their owners. For instance, on the smooth "kankar" roads of the Punjab, which in wet weather become sticky and slippery, camels are utterly unable to progress, their washleather-like padded feet sliding from under them, and rendering them as helpless as a cat on ice.

Although, in a literal sense—that is to say, from the fact that they "chew the cud"—the members of the camel tribe are ruminants, yet they are structurally very different from the true ruminants—the Pecora of zoologists—and are consequently referred to a separate group of equal value, for which the aforesaid name of *Tylopoda* is now in general use.

In addition to their cushion-like feet, camels (including now and hereafter all the existing members of the group and their immediate ancestors under this title) are broadly distinguished from the true ruminants by the following features:—

In the first place, instead of having the front of the upper jaw entirely toothless, the full series of three pairs of incisor teeth are present in the young, while in the adult the outermost of these pairs are an isolated curved and pointed tooth, and there is also a well-developed pair of canines, or tusks. Again, the lower canines, in place of being approximated to the incisors and resembling them in shape, retain the more usual isolated position and sharply-pointed form. As regards the cheek-teeth, although the majority of these are of the crescentic type characteristic of all ruminating mammals, yet there are certain peculiarities in form whereby they are readily distinguished from those of the true ruminants; and, what is more important still, one or more at the front of the series are usually detached from those behind, and assume a sharply-pointed form.

In the skeleton the thigh-bone, or femur, is placed much more vertically, by which means the thigh is much more distinct from the flank, while the knee-joint is placed lower down than in the true ruminants. Another peculiarity is to be found in the unusual length and pointed form of the knee-cap, or patella. Then, again, none of the bones of the wrist and ankle-joints (carpus and tarsus) are welded together. As regards the lower part of the limbs, although the upper segments of the two remaining toes (the third and fourth of the typical series of five) are welded together to form a cannon-bone (fig. 1); yet they diverge to a much greater extent at their lower extremities than is the case with the true ruminants. Moreover, in place of each of the two lower articular surfaces of the cannon-bone having a projecting ridge to fit into a groove in the upper surface of the uppermost toe-bone, such surfaces are perfectly plain and smooth (fig. 1). Probably, owing to the nature of the foot itself, there is less liability to dislocation than in the hoofed feet of the true ruminants, and a "tongued joint" is therefore unnecessary. As regards the toe-bones themselves, it will suffice to say that the third or terminal pair form small irregular nodules, quite unlike the symmetrically flattened form characterising those of the true ruminants.

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Perhaps, however, the most important peculiarity in the skeleton of the camels (and it will be unncessary on this occasion to refer to the soft-parts) is to be found in the vertebræ of the neck, which are unusually elongated. In all other mammals, with the exception of the extinct South American macrauchenia, the canal for one of the great arteries for the neck perforates the process projecting from each side of the vertebræ; but in the camels and macrauchenia it runs obliquely through the side-wall of the tube for the spinal marrow.

Fig. 1.—Front Cannon-Bone of a Camel.

All these features combined serve to show that the camel tribe is widely separated from the true ruminants. How far back we have to go before we come to the common ancestral stock is indeed at present uncertain. Possibly both groups are independently derived from primitive ungulates in which the cheek-teeth had not yet developed a crescentic type of structure. Be this as it may, it is quite certain that the ancestral camels had low-crowned cheek-teeth, comparable to those of the ancestral horses.

Indeed, making due allowance for the fact that in the one case the modification has been carried on the artiodactyle, and in the other on the perissodactyle plan (that is to say, with the enlargement of the third and fourth toes, instead of the third alone), the evolution of the camels has followed much the same lines as that of the horses. And this is only what might have been expected, since, as stated in the previous article of this series, it is only on such lines that we can conceive evolution of this nature to be possible.

As examples of this general similarity, or parallelism, I may refer, in the first place, to the enormous increase in bodily size which has taken place. Equally noticeable is the elongation of the bones of the lower segments of the limbs, coupled with the tendency to do away with double bones in such of those segments as they exist, the suppression of the lateral digits, and the enlargement of those which remain. In both cases there is likewise a progression from low-crowned to tall-crowned cheek-teeth, and in both the development of a bar of bone beyond the eye so as to enclose its socket in a complete bony ring.

The combination of all these factors tends (in addition to the augmentation of bodily size) to increase the speed and the longevity of the animals, and at the same time to render them fitted to subsist on the vegetation characteristic of the present and immediately preceding epochs; the strengthening of the limbs so as to enable them to support the increased weight, and at the same time to withstand the strain of the increased speed, being, of course, an essential feature of the process.

Apart from certain still older and more primitive mammals, with teeth of the tubercular type, the earliest known form which can definitely be included in the camel series is *Protylopus*, of the Llinta, or Upper Eocene period of North America. In this creature, which was not larger than a European hare, there was the full typical number of 44 teeth, which formed a regular series, without any long gaps, and with the canines but little taller than the incisors, while the hinder cheek-teeth, although of the crescentic type, were quite low-crowned. In both jaws the anterior front teeth were of a cutting and compressed type. Unfortunately, the skull is incomplete, and the rest of the skeleton very imperfectly known; but sufficient of the former remains to show that the socket of the eye was open behind, and of the latter to indicate that in the hind foot, at any rate, the upper bones of the two functional toes had not coalesced into a cannon-bone. The lateral hind toes (that is to say, the 2nd and 5th of the typical series) had, however, already become rudimentary; although it is thought probable that the corresponding digits of the fore-limb were functional, so that this foot was four-toed. Very remarkable is the fact that in old individuals the bones of the fore-arm (radius and ulna) became welded together about half-way down, although they remained free above. On the other hand, it appears that the smaller bone of the leg (fibula) was welded to the larger one (tibia), and that its upper portion had disappeared. Nothing is known of the neck-vertebræ. It is, of course, evident that there must have been an earlier form in which all the feet were four-toed, and the bones of the fore-arm and lower part of the leg separate.

A stage higher in the series, namely, in the Oligocene, we meet with the much better known *Poebrotherium*, the skull of which (fig. 2) was described so long ago as 1847. In this animal, which is also American, a distinct increase

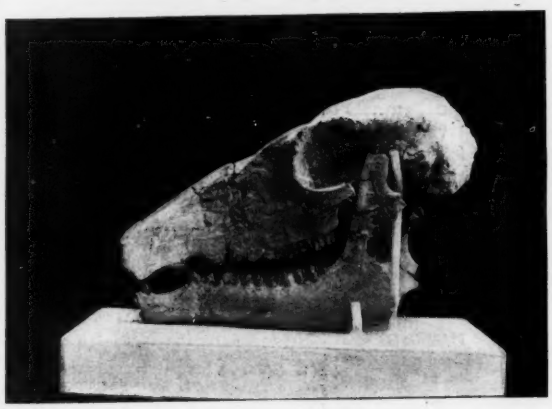

Fig. 2.—Skull of Poebrotherium

in bodily size is noticeable, as is also one in the relative length of the two bones which unite in the higher types ot form the cannon-bone. Moreover, the crowns of the hinder cheek-teeth are rather taller and more distinctly crescentic, both feet are two-toed, the ulna and radius were fused, and the fibula was represented only by its lower part. In the vertebræ of the neck the distinctive

cameloid characters had already made their appearance. On the other hand, the skull (fig. 2) was short and rabbit-like, showing none of the characteristic features of those of the modern camels.

Reaching the period of the Lower Miocene, we come to a genus, *Gomphotherium*, in which there is a considerable increase in the matter of bodily size, the two metapodial bones (or those which unite in the later forms to constitute the cannon-bone) being fully double the length of the corresponding elements in *Protylopus*. Moreover, these bones, although still separate, have their adjacent surfaces much more closely applied than is the case in the latter. Again, in this and the earlier genera the terminal toe-bones indicate that the foot was of the normal hoofed type. On the other hand, in the skull (fig. 2) the socket of the eye is completely surrounded by bone; while the dentition begins to approximate to the camel type—notably by the circumstance that the lower canine is either separated by a gap from the outermost incisor, or that its crown assumes a backwardly curved shape. Brief mention must suffice for *Protolabis* of the Middle Miocene, in which, while no cannon-bone is formed, the first and second pairs of incisor teeth are retained, and the limbs and feet are short and disproportionately small.

In the Upper Miocene, on the other hand, we come to a very distinct type—*Procamelas*—which is clearly entitled to be regarded as a camel, and approximates in size to a small llama. Here the metapodials have at least partially united to form a cannon-bone; the skull has assumed the elongated form characteristic of modern camels, with the loss of the first and second pairs of

Fig. 3.—The Bones of the Hind-Foot of Poebrotherium, showing the distinct metatarsals, which coalesce in the higher forms into the cannon-bone.

upper incisors, and the development of gaps in front of and behind each of the next three teeth, that is to say, the third incisor, the canine, and the first cheek-tooth. The approximately contemporaneous *Pleanchenia* makes another step by the loss of the second lower cheek-tooth. Both these genera have the toe-bones of the irregular nodular form distinctive of the modern camels, so that we may safely infer that the feet themselves had assumed the cushion type.

In one species of *Procamelus* the metapodial bones coalesced into a cannon-bone late in life; but when we come to the Pleistocene *Camelops* such union took place at an early stage of existence, and was thoroughly complete. In the living members of the group it occurs

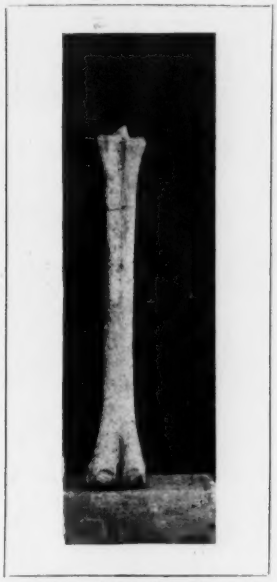

Fig. 4.—Hind Cannon-bone of a modern Llama to contrast with the foot of "Poebrotherium," and to show the type characteristic of "Procamelas" and higher forms.

even before birth. The species of *Camelops* were probably fully as large as llamas (including guanaco and vicuna), and some of them, at any rate, resembled these animals as regards the number of teeth, the incisors being reduced to one upper and three lower pairs, and the cheek-teeth to four or five in the upper and four in the lower jaw; the total number of teeth thus being 28 or 30 in place of the 44 of *Poebrotherium*. The sole difference between *Camelops* and *Llama* seems to consist in certain structural details of the lower cheek-teeth. An allied extinct genus (*Eschatius*) is also distinguished by certain features in the dentition.

All the foregoing genera are exclusively North American. A lower jaw from the Pleistocene deposits of that Continent has, however, been referred to the true camels (*Camelas*), which differ from the llamas, among other features, by their greater bodily size, well developed hump, or humps, the presence of five pairs of lower cheek-teeth, and the complete bony ring round the socket of the eye.

Outside America, remains of true camels are met with in the Lower Pliocene Siwalik strata of India, as well as in the Pleistocene of South-Eastern Europe and Algeria; and it is noteworthy that the cheek-teeth of the Siwalik camel (*Camelus sivalensis*) display a structural feature now exhibited by those of the llamas. From Pleistocene or Pliocene in China have been obtained remains of a large camel-like animal named *Paracamelus*, which also shows certain signs of affinity with the llamas in respect of its cheek-teeth.

The above survey, brief as it is, suffices to show that the huge camels of the present day have been gradually evolved from creatures not bigger than a hare, on lines closely paralleled in the case of the horse. In one

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respect the camels have indeed beaten the horse, having entirely got rid of the splint-bones representing the outermost pair of the original four toes. Further, in having exchanged the hoofed for the cushioned type of foot, they have undergone a kind of retrograde development, for which there is no parallel in the horse line.

Fig. 5.—Skull of Modern Camel, showing the reduced number of upper incisor teeth, and the ring of bone round the eye-socket.

Here a brief diversion must be made to notice an extraordinary North American Miocene form, which is off the main line. This is the giraffe-necked camel (*Alticamelas*), a creature of the size of a giraffe, with similarly elongated neck and limbs, and evidently adapted for browsing on trees. The feet and number of teeth were generally similar to those of *Procamelas*. Unlike the giraffe, the length of the limbs is due to the elongation of the bones of the upper segments (femur and tibia) and not the cannon-bones; while the fore-limbs are not higher than the hind ones. The length of neck is due to the elongation of the anterior neck-vertebræ; if the hinder ones had been lengthened, the height of the body would have been increased without any compensating advantage. This creature affords one of the most extraordinary instances of special adaptation known to science.

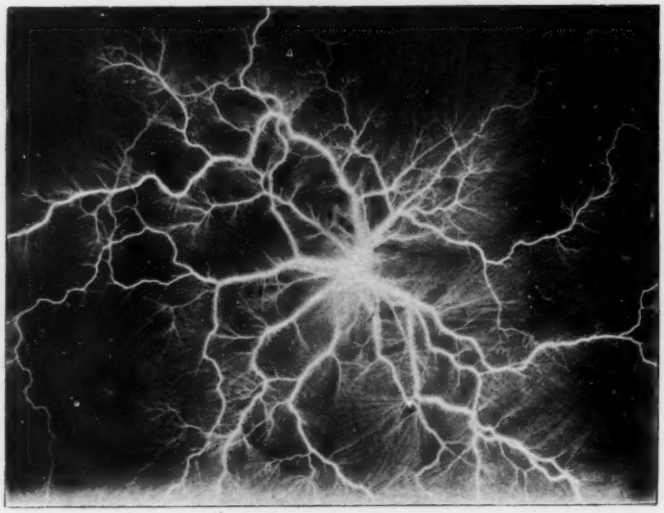
The remaining space at my disposal must be devoted to certain considerations concerning the birthplace and geographical distribution of the group. It is claimed by Transatlantic palæontologists that North America was the original home of the *Camelidæ*, and so far as the earlier members of the group are concerned, there is nothing at present to justify a contradiction of this. The case is, however, very different with the latter forms. We have seen that in North America the formation of a complete cannon-bone did not take place till the Pleistocene, at which epoch true camels also made their first appearance. But such camels, with complete cannon-bones, were in existence in India in the early Pliocene. Obviously, therefore, the evolution of these animals must have taken place somewhere in Asia; this view being supported by the occurrence there of the aforesaid *Paracamelas*. Hence it is quite probable that some of the earlier stages of the evolution of the group may have been carried out in Asia, when that continent was united by way of Behring Strait with North America. The Siwalik camel, it may be added, may have given rise to the existing two-humped Bactrian species; while from the extinct Russian and Roumanian camels the single humped Arabian species may have sprung.

With regard to the llamas of South America, palæontology goes to prove that the ancestral forms first obtained entry into that continent from the north during the Pliocene period, when free communication was established between North and South America. Now all these ancestral forms, of which there are several distinct generic types, appear to have complete cannon-bones. Consequently, unless we are prepared to admit that these compound bones have been independently evolved in the camels and the llamas, the latter cannot have been derived from the known North American Pliocene forms, in which the union of the constituent elements of these compound bones was incomplete. Consequently, it seems a probable supposition—and this is supported by the above-mentioned structural resemblance between the cheek-teeth of the Siwalik camel and those of the llamas—that the latter animals, like the true camels, were evolved in Eastern Central Asia, whence they reached South America by way of the Pacific border of the northern half of the New World, possibly over land long since submerged.

The Photography of Electric Sparks.

THE Photography of Some Electrical Phenomena was the subject of a lecture delivered on January 25, 1904, at the Camera Club, Charing Cross Road, by Dr. George H. Rodman.

The lecturer commenced by describing the method that he had adopted in obtaining the photographic representation of electric sparks from a 10-inch induction coil actuated by accumulators. It seemed to matter but little what voltage was used in the primary circuit, and the results shown were produced at a voltage varying from 6 to 24 in the primary.



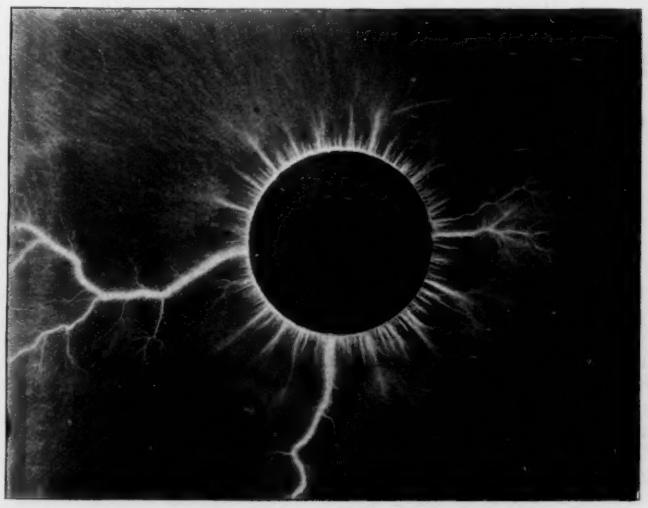
Single Positive Discharge.

Single and multiple discharges were discussed; the former occupying a very short space of time, possibly about $\frac{1}{20,000}$ of a second. Numerous representations of sparks taken under different conditions were shown, and

Single Discharge between Points.

attention was called to the marked difference between the positive and negative discharge, the former having a brush-like appearance, and the latter invariably showed a characteristic fern-like representation on the plate.

The lecturer showed excellent examples of the increased intensity of the spark when a spark gap was introduced into the secondary circuit, and in passing re-



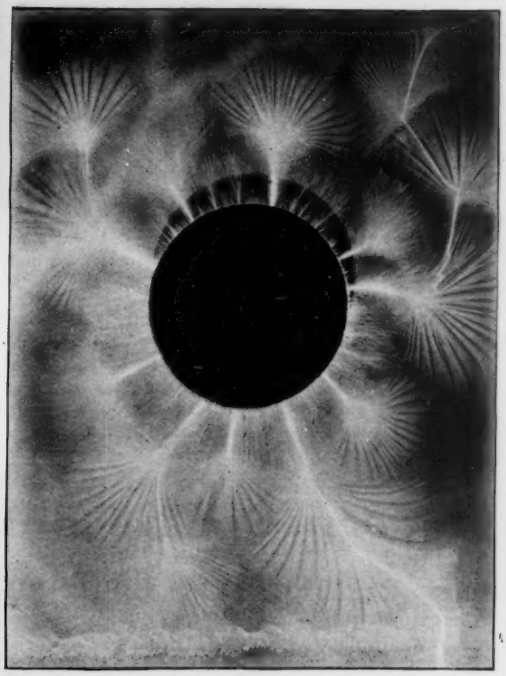
Single Positive Discharge on Florin.

marked that this was the explanation of the use of a spark gap employed in connection with the sparking plug of motor vehicles.

Examples of sparks from brushes and spheres, in addition to ordinary point discharges, revealed many extraordinary effects; and in all the characteristic features of the positive and negative discharges were invariably present. The results, Dr. Rodman explained, were obtained on Imperial plates, which were subsequently developed in the usual manner with a pyro soda solution.

The production of the photographic image of coins placed on the surface of the emulsion, and connected up with one or other terminals of the coil furnished some highly interesting results; and in these cases the characteristic features of the positive and negative discharges were well shown.

On passing a single discharge on these coins with subsequent development of the latent image, a very distinct representation of the coin with its inscription clearly legible was produced, and the same effect was obtained in a much



Single Negative Discharge on Coin.

clearer manner when a multiple discharge of current extending to 1-20th sec. was used.

In this experiment when a discharge was produced with two coins attention was called to the remarkable appearance that the plate on development presented—the image of both coins being multiple. Dr. Rodman stated that he had up to the present been unable to determine the cause of these multiple images, and, in order to arrive at a conclusion as to the cause of these nimbus-like shadows, had adopted various devices, but had failed with them to elucidate the matter.

Assuming that they were the result of reflection, films had been used instead of the glass plates employed in the other experiments. Backed plates had also been made use of, but the multiple shadows still presented themselves. To exclude the possibility of their being pro-

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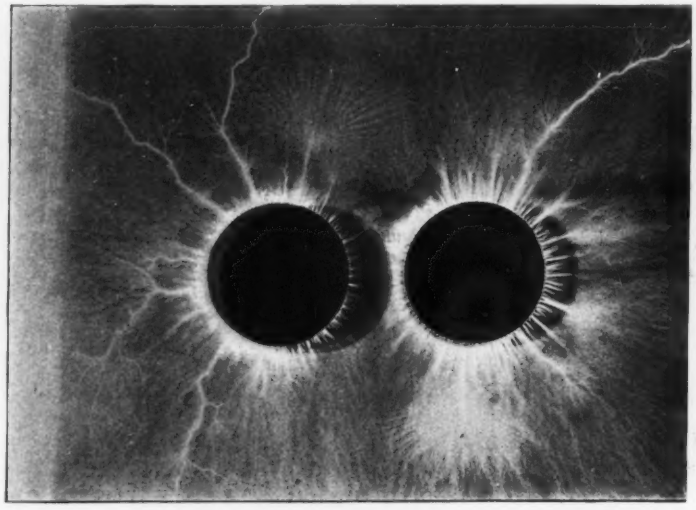
duced by reflection from the edges of the coins, these had been painted with non-actinic colour.

Finally, it was thought that the coins might have been thrown into a state of agitation, and had moved during the passage of the current, and to exclude this possibility they had been enclosed and supported in a couple of circular holes made to fit the coins in a card at the time of exposure. This peculiar feature of the experiment was met with when coins of unequal size and of varying metals were employed, and was also noticed when the glass insulating plate was replaced by an india-rubber pad.



Single Positive Discharge on two Coins. Both Coins in Spherical Connection.

Modern Cosmogonies.

VII.—Cosmogony in the Twentieth Century.

By MISS AGNES CLERKE, F.R.A.S.

PROSPECTIVE and retrospective inquiries into physical conditions stand very much on the same footing. The same degree of uncertainty attaches to results of both kinds; the same qualifications need to be applied to them; a similar reserve is understood to accompany our admission of them. The reserve grows more marked as science unfolds to our surprised apprehension the multiplex possibilities of Nature. The time has gone by when "men of light and leading" could draw cheques for unlimited amounts on the bank of public credulity. Not that the balance has diminished, but that it is otherwise employed. Most of us, in these days, have learnt to "look before and after" for ourselves; and we instinctively mix the proverbial grain of salt with what is told to us, even on the highest authority. Ideas are on the move; dim vistas are opening out; much that lies beyond the verge of actual experience is seen to be possible, and sedate reasoning may at any moment suffer outrage by fantastic discovery. Hence, dogmatism is at a discount.

The secular parallax affecting men's views of the universe is nowhere more strongly apparent than in the trend taken by speculations as to its origin. They have become more subtle, more far-reaching, yet less confident. They have ramified in unexpected directions, but rather tentatively than with the full assurance of attaining absolute truth. Laplace considered only the solar system, from which he arbitrarily excluded comets; on the vast sidereal world he bestowed barely casual attention. Sir William Herschel, on the other hand, occupied himself exclusively with the growth-processes of nebulæ, relegating the details of planetary evolution to a position of secondary importance. Later, the spectroscope having become available for discriminating generic differences among the suns in space, their relative ages, the order of their succession, their mutual affinities, claimed predominant attention. Just now, however, the flood of ideas is too high to be restrained within separate channels; cosmogonists look far afield; they aim at obtaining a general survey of relations baffling in their complexity. To some extent they have succeeded; parts are beginning to find their places in a great whole; links are seen to connect phenomena at first sight seemingly isolated; on all sides, analogies are springing into view. The unwearied circling of the moon, and its imperturbable face, remind us how a sun may have been born; the flash of every meteor suggests the mode by which suns die. The filmy traceries of comets intimate the nature of the force acting in nebulæ; the great cosmic law of spirality is distantly hinted at by the antipodal disturbances of the sun. Thus, one set of facts dovetails into the next; none can be properly considered apart from the rest.

The limitations of the human mind, nevertheless, require a subdivision of labour. Individual efforts cannot grapple with the whole of the known and the knowable; and the larger part of both is included in the scope of modern cosmogony. It deals with all that the skies hold, visibly or invisibly; draws unstintingly on time past and time to come; concerns itself equally with gradual transformations and sudden catastrophes, with the dissipation and concentration of energy, with the subtle interplay of matter and force, with physical and ultra-physical, chemical and electrical modes of action. But let us consider a little more particularly how things actually stand, so as to collect some definite ideas regarding the lines of advance practicable and promising for the immediate future.

To begin with our domestic circle. The insecure state to which Laplace's scheme has been reduced by the assaults of numerous objectors has found compensation in the development of tidal theory. Much light has thereby been thrown upon planetary pre-history. The relations of planets to the sun, and of satellites to planets, have been rendered comparatively intelligible. Noticeable above all is the discovery thence ensuing of the earth's critical situation, just outside the boundary of the region where planetary rotation was destroyed by sun-raised tides, and with it the prospects of planetary vitality. Moreover, the consequent dubious state of the inchoate terrestrial spheroid accounts for the peculiar mode of birth of the moon, and the distinctively binary character of the earth-moon system; while the variety perceptible in the circumstances of the different planets precludes the employment of any single recipe for their

development from a primal vortex. The forces concerned, we can now see, acted in a far more complex manner than could formerly have been supposed; and their balance was proportionately more delicate. To which side it would have inclined in a given case must then often be incalculable, or calculable only with the guidance of the known result. The strict bonds of reasoning have thus become somewhat relaxed, and difficulties that looked formidable have, in the long run, proved not to be insuperable. But conviction has also grown faint. The old, imposing façade of theory remains erect; the building behind it has been for the most part pulled to pieces, and the architect has yet to be found who can reconstruct it to our satisfaction.

On one point we have, nevertheless, acquired certainty. It is now known that comets with their dependent trains of meteors are aboriginal in the solar system. They are no unlicensed intruders, but collateral relations of the planetary family. Possibly, they represent waste scraps of world-stuff which escaped the action of the formative machinery; and if so, they exemplify its primitive texture. Not that their composition need be, on this supposition, identical with that of the planets. A sifting of elements would have been likely to accompany the processes of cooling and contraction. Comets were perhaps made (so to speak) of the white of the nebulous egg, planets of its yolk. But in any case, we may safely regard the glimmering fabrics of acetylene and cyanogen that occasionally illuminate our skies as shearings from a wide-spreading, fleecy haze, flung aside before "the starry tides" had as yet begun to "set towards the centre." In one respect, the quality of these relics is a surprise. They show no chemical affinity with nebulæ. Their spectra are radically different from nebular spectra, gaseous or continuous. They accordingly lend no countenance, although not fatally adverse to the view that the sun was once, in the distinctive sense, a nebulous star.

The grand topic of sidereal succession is no longer abandoned to fruitless surmises. Broad lines have been laid down, along which—so far as we can at present see—progress must inevitably have been conducted. And one fact of overwhelming significance in this connection is entirely of recent discovery. The multitudinous existence of obscure bodies in space had, indeed, been foreseen as a logical necessity long before Bessel founded the "Astronomy of the Invisible"; but it has been substantiated almost wholly by modern spectrographic methods. Decrepit or dusky suns are assuredly no imaginary product, but a potent reality; though it would be too much to assert that all have sunk to extinction by the same road.

We stand, too, on firmer ground than our predecessors in respect to the history of stellar systems. That its course is mainly prescribed by the influence of tidal friction has been ably demonstrated by Dr. See. Telescopic double stars can be led back, by the aid of this clue, to an initial stage, when they revolved close together, very much like the earth and moon in Professor Darwin's theory; and it was owing to their voluminousness, and the unequal attractions it engendered, that their orbits became enlarged and elongated to the degree generally observed. Spectroscopic binaries, moreover, illustrate earlier modes of circulation; they present us with couples fully separated, and still separating, as well as with others barely divided, and revolving almost in contact. Nay, they include specimens, we are led to believe, of globes conjoined into the apioidal figure theoretically investigated by Darwin and Poincaré, which may be regarded as preparatory to the development, by fission, of two mutually revolving stars from one primitive rotating mass. One of these supposed dumb bell systems is the variable V Puppis; and if the eclipse-rationale of its obscurations be confirmed by the spectroscope, there is no gainsaying the inference that it is composed of two stars actually contiguous, if not commingled.

Now compound stars are by no means of exceptional occurrence. Their relative abundance has been found to augment rapidly with every advance in our knowledge of the heavens. From the measures of stellar radial velocity lately carried on at the Yerkes Observatory by Professors Frost and Adams, it appears that the proportion of binary to single stars considerably exceeds Professor Campbell's earlier estimate. Of those giving helium-spectra, at any rate, there are most probably as many of one kind as of the other. But why the distinction, it may be asked; and the answer is not far to seek. Helium-stars are the most primitive, and form the closest, and most readily apparent systems. A physically double star must always remain such. There is no law of divorce by which it can put away its companion, although their relations must alter with time. But their alteration tends continually to enhance the difficulty of their detection. For as the members of a pair are pushed asunder by tidal friction, their velocity slackens, and the tell-tale swing of their spectral lines diminishes in amplitude, and finally, by its minuteness, evades observation. And since the majority of spectroscopic satellite-stars are very imperfectly luminous, their eventual telescopic discovery, when far enough away from their primaries to be optically separable from them, would rarely ensue. It must then be concluded that half the stars in the heavens (let us say) broke up into two or more bodies as they condensed. What follows? Well this. Half the stars in the heavens were, from the first, incapacitated from becoming the centres of planetary systems. To our apprehension, at least, it appears obvious that a binary condition must have inhibited the operations of planetary growth. These innumerable systems are doubtless organised on a totally different principle from that regulating the family of the sun. The Nebular Hypothesis, even in its most improved form, has no application to them; the Meteoritic Hypothesis still less. Mathematical theories of fluid equilibrium, combined with a long series of changes due to tidal friction, afford some degree of insight into the mode of their origin and the course of their development. Yet the analogy with the earth-moon couple, which irresistibly suggests itself, is imperfect, and may be misleading, owing to the wide difference in state between plastic globes approaching solidification and sun-like bodies, radiating intensely and probably gaseous to the core.

The world of nebulæ presents us with complete cycles of evolutionary problems, which can no longer be treated in the offhand manner perforce adopted by Herschel. The objects in question are of bewildering variety; yet we can trace, amid their fantastic irregularities, the underlying uniformity of one constructive thought. Nearly all show, more or less markedly, a spiral conformation; and a spiral conformation intimates the action of known, or discoverable laws. Their investigation must indeed be slow and toilsome; its progress may long be impeded by the interposition of novel questions, both in physics and mechanics; nevertheless, the lines prescribed for it seem definite enough to give hope of its leading finally to a clear issue. And when at last something has been fairly well ascertained regarding the past and future of nebulous spirals, no contemptible inroad will have been made on the stupendous enigma of sidereal relationships.

XUM

Its aspect, if we venture to look at it in its entirety, is vast and formidable. Not now, as in former times, with a mere fragment of creation—a single star and its puny client-globes, one of which happens to be the temporary abode of the human race—but with the undivided, abysmal cosmos, the science of origin and destiny concerns itself. The obscure and immeasurable uncertainties of galactic history invite, or compel attention. We know just enough to whet our desire to know a great deal more. The distribution of stars and nebulæ is easily seen to be the outcome of design. By what means, we cannot but ask ourselves, was the design executed? How were things ordered when those means began to be employed? How will they be ordered when all is done? For an ultimate condition has, presumably, not yet been reached. And if not, agencies must be at work for the perfecting of the supreme purpose, which are not, perhaps, too subtle for our apprehension. Meanwhile, facts bearing on sidereal construction are being diligently collected and sifted; and we shall do well to suspend speculation until their larger import is made known.

The inquisitions of science do not cease here. They strive to penetrate a deeper mystery than that of the scattering in space of stars and nebulæ. What are they made of is the further question that presents itself. What is the nature of the primal world-stuff? Whence did it obtain heat? By what means was motion imparted to it? If it be urged that such-like topics elude the grasp of finite intelligence, and belong to the secrets of Creative Power, we may reply that we are not entitled, nor are we able to draw an arbitrary line, and impose a *ne plus ultra* on our thoughts. The world has been, by express decree, thrown wide to their excursions, and it is not for us to restrict their freedom. We need not fear getting too near the heart of the mystery; there is no terminus in the Unknown to which we can travel by express; in a sense, we are always starting, and never get nearer to our destination. But that is because it retreats before us. We do, in truth, advance; and as we advance, the mists clear, and we see glimpses beyond of imperishable order, of impenetrable splendour. Our enquiries need not then be abandoned in despair at the far-reaching character they have spontaneously assumed.

From the earliest times there has been a tendency to regard varieties of matter as derivative. They have been supposed to be procured, by supra-mundane agency, or by the operation of inherent law, from some universal, undifferentiated substance. We moderns call that substance "Protyle,"* and believe ourselves to be in experimental touch with it. The implications of this view we shall consider in the next chapter.

* A term signifying "first matter," constructed from corresponding Greek words by Roger Bacon, and revived by Sir William Crookes.

The Conductivity of Selenium.

Mr. E. A. Hopius, in an investigation recently presented to the Russian Physico-Chemical Society, has made a series of experiments with an apparatus constructed by Mr. M. Kohl and another apparatus designed by himself on selenium supplied by the firm of E. Merk, Darmstadt, the former apparatus being illuminated by a standard amyl acetate burner at distances ranging from 10-200 cm., and the other by a Nernst lamp placed at the same distance. The measured current intensity agreed fairly well with the hypothesis of a direct proportionality between the increase in the conductivity of selenium and the cubic root of the intensity of illumination.

Borings on a Coral Island.

The Atoll of Funafuti.

NEARLY a quarter of a century ago Charles Darwin penned the following words in a letter to Prof. Alexander Agassiz: "I wish that some doubly rich millionaire would take it into his head to have borings made in some of the Pacific and Indian atolls, and bring home cores for slicing from a depth of 500 or 600 feet." The profound interest which Darwin had himself long previously aroused by his theories regarding the structure of coral reefs and their mode of origin could not do otherwise than henceforth make the subject an integral part of geological science, and one, too, of striking significance. It was, therefore, to be expected that the hopeful words of the master-naturalist would ripen with time to bear fruit in effort. Not, however, until 1893 did

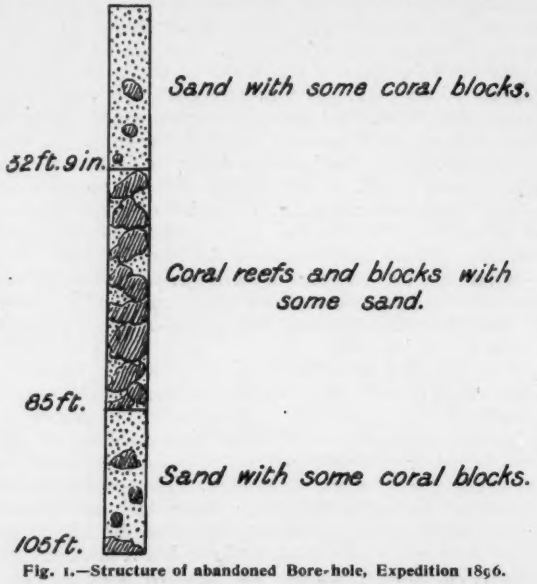


Fig. 1.—Structure of abandoned Bore-hole, Expedition 1896.

a project for such a survey become fairly launched, and then chiefly through the strenuous endeavours of Prof. W. J. Sollas, F.R.S., who succeeded in at last promoting a "Coral Reef Committee." Prof. T. G. Bonney, F.R.S., assumed the chairmanship, and on this body several of the most competent among English geologists, with other authorities, consented to serve. It is unnecessary to say that, whatever the latter-day millionaire may do for science, none made his appearance at this initial stage.

The primary idea was to investigate, by means of a boring, the depth and structure of an oceanic coral reef, and thus make it tell its life story. Ultimately it was decided to attack the problems surrounding the question at Funafuti, an island in the Ellice Group in the Pacific Ocean, and a comprehensive scheme for an exploring Expedition was drawn up in 1896, Professor Sollas being unanimously designated as leader. Although the difficulties that lay in front were by no means underrated at the commencement, yet the news of the failure of the first attempt in 1896 was indeed unwelcome. (Fig. 1.) However, nothing daunted, a second Expedi-

tion was organised in 1897, under the direction of Prof. T. W. Edgeworth David, of Sydney, and a third in 1898, with Mr. A. F. Finckh as leader, for the further prosecution of the work. The final result was the achievement of a drill boring to the extraordinary depth of 1114½ feet, and the bringing of a core, by which means the composition of an atoll in its zoological and chemical aspects has been actually determined. How rejoiced the great naturalist of Down would have been could he have lived to witness the realisation of his wish. We can picture his eagerness to write at once to Hooker, and to Wallace and Agassiz. His personal opinions regarding the development of coral reefs would not have weighed for an instant, since his open mind had already dictated the characteristic sentence, "if I am wrong, the sooner I am knocked on the head and annihilated, so much the better."

Fig. 2.—Model of Atoll, showing general shape and Submarine contour.

Although much scientific literature has centred around Funafuti in the intervening years, it has not been possible to pilot the whole scientific story of the borings

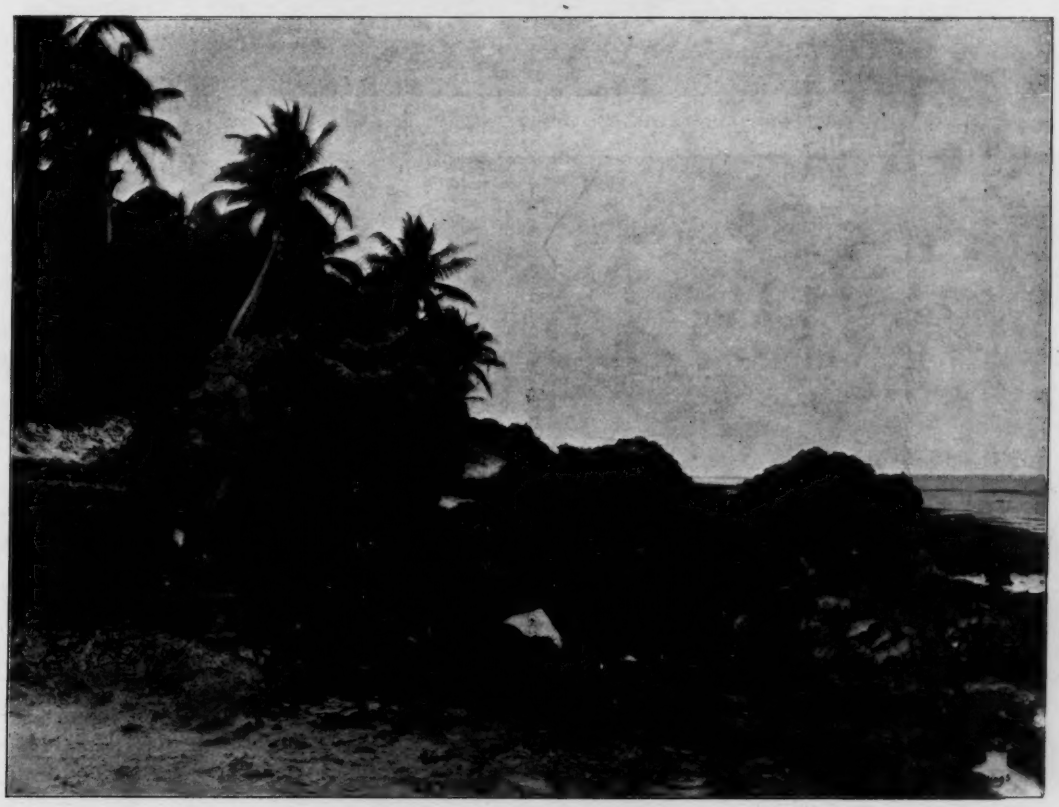


Fig. 3.—Hard Breccia Masses on Shore.

to completeness until to-day, but it is now told in a handsome monograph just issued by the Royal Society, to which source we are indebted for our illustrations.

The configuration of the atoll is seen on reference to the model (Fig. 2), and its fanciful resemblance to the shape of a human head (view from the compass letter S) has not escaped notice. The longest continuous stretch of reef is 16 miles in length, and the most elevated point above high water, 16 feet; while the general depth of the waters of the lagoon is about 20 fathoms. One peculiar feature of the atoll is its submarine cliff, re-

Fig. 4.—Hurricane Beach, Funafuti, and living "Lithothamnion" Reef.

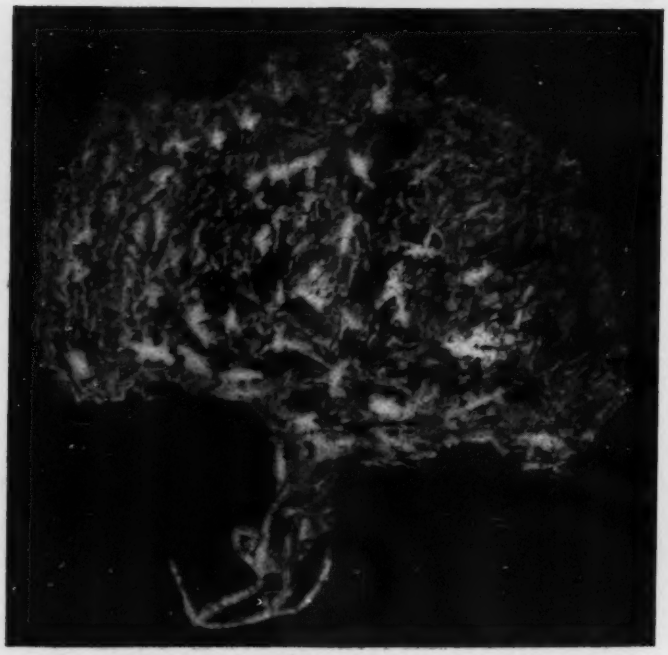


Fig. 5.—A Cluster of the alga "Halimeda."

garding which Professor Edgeworth David remarks that were the whole atoll elevated 140 fathoms, it would enable the portions above the sea-level to present a cliff face 300-600 feet in height.

Although we speak of Funafuti as a coral island, in its fauna corals are the accessory rather than the essential reef-builders, and of the latter none are more abundant and contributory to reef-rock than the calcareous algæ *Lithothamnion* and *Halimeda*. Indeed, a classification of the chief reef-forming organisms assigns their relative importance thus:—(1) Species of *Lithothamnion*, (2) *Halimeda*, (3) *Foraminifera*, (4) *Corals*. And Mr. Finckh, in a biological chapter, tells us, further, that a coral once established adds to the coral island by its growth only in the same way as a tree once established adds by its growth to the extent of a forest. In the living state and by itself it cannot form a solid mass; dead, however, its skeleton supplies material which the *Lithothamnion* and *Halimeda* unite together with the remains of other calcareous organisms to make reef-rock —mounting thus "On stepping stones of their dead selves to higher things." (Figs. 3, 4.)

Some interesting experiments were conducted relative to the effect of exposure to the

sun's rays and the powers of endurance to heat of corals and of *Lithothamnion*, a point on which Darwin had speculated. It seems that except the *Porites*, all other forms of coral succumbed within two hours' exposure, and it was evident that the essential life-gift alike to coral and plant was a constant supply of fresh sea-water.

Among the contributions to the monograph certainly the most industrious of all is Dr. Hinde's report on his examination of thin sections of the materials obtained from the reef borings and those made beneath the floor of the lagoon. Upwards of 500 microscopic surface slittings were prepared for diagnosis in Professor Judd's geological laboratory at the Royal College of Science. As already mentioned, the main boring, begun in 1897, was taken down to 1114½ feet, and it may be added that the diameters of the cores brought up in the drilling apparatus were, top to 68 feet, about 4 inches; 68-210 feet, about 3¼ inches; 210 to boring limit, about 2¼ inches. All these cores ranged in length from 1 inch to 3 feet. Dr. Hinde supplies an elaborate description of a detailed inspection of the several lengths of core that were placed under examination for the detection of organisms, and we cannot do better than quote here Professor Judd's general conclusion thereon, namely, that "from top to bottom the same organisms occur, sometimes plants, sometimes foraminifera, and sometimes corals predominating; but in the whole depth bored the same genera and species of these various groups of organisms take their part in the building up of the mass." (Fig. 5).

A large amount of space would be necessary to even summarize the many points of research apart from boring and sounding operations embraced by this truly classic exploration in the far Pacific. There was made, however, we must not omit to mention, a magnetic survey by H.M.S. *Penguin* (Captain Field); a series of meteorological observations; and a thorough study of the natural history of the island of Funafuti.

The numerous helpers in the two continents have reason to be proud of the evidence of their long-continued efforts, and undoubtedly the scientific results of the survey will prove of the utmost value in current discussions which concern the present-day revised view of the development of coral reefs.

Modern Views of Chemistry.

By H. J. H. FENTON, F.R.S.

IT may happen that there are some of our readers who are interested in the study of Chemistry, but who have not had the time or opportunity of following the very rapid and important advances which have been made in the science, especially in the departments of physical and organic Chemistry. In the present articles, which are addressed to readers of this class, it is proposed to give brief sketches in outline of some of the more important developments which have occurred during recent years.

We will in the first place refer to the great changes which have occurred in our views with regard to the nature of solution and the chemical and physical changes which may take place in dissolved substances; the advance of knowledge in this department has resulted in what is sometimes called the "New Chemistry," which would scarcely be recognised as the same science by one who had been a good chemist twenty-five years ago, but who had not kept pace with the times.

It may be mentioned in passing that it was the custom formerly to restrict the term "solution" to liquid mixtures—that is to solids, liquids, or gases dissolved in liquids; but we may now speak of solutions of gases in solids and even of solids in solids; a solution is in fact, generally speaking, any homogeneous mixture of two (or more) substances in which the proportions may, within certain limits, be varied continuously. Usually one speaks of one of the constituents as the solvent and the other as the dissolved substance or "solute"; but this is only an arbitrary distinction. In the case of an aqueous solution of common salt, for example, we might regard the mixture either as a solution of salt in water or of water in salt; for if a dilute solution be sufficiently cooled it becomes saturated with respect to water, and solid water (ice) separates out, leaving a stronger solution of salt, just as when a very strong solution is cooled it becomes saturated with respect to salt, and the latter separates in the solid state, leaving a weaker solution of salt, *i.e.*, a stronger solution of water. It was at one time thought that solution consisted in a sort of loose chemical combination between the solvent and dissolved substance, and this idea seemed to be supported by the fact that many salts and other substances combine with water to form definite hydrates, which may be isolated in the crystalline form. But it does not follow that these hydrates continue to exist when the substance is in solution, and the probability is that, in dilute solution at any rate, they do not exist.

Certain membranes exist naturally, and may be prepared artificially, which will allow water to pass through them, but will not allow the passage of dissolved substances such as sugar, salt, &c. If now one separates a solution of sugar from pure water by means of a membrane of this kind water will pass both ways through the membrane, but more will pass into the sugar solution than out of it, so that its volume tends to become larger and the solution weaker. If, however, the volume of the solution is kept constant, that is, if it is not allowed to expand, the pressure will increase instead, and will continue to do so until a certain maximum pressure is reached. This maximum (osmotic) pressure depends upon the temperature, the strength (or concentration) of the solution, and the nature of the dissolved substance. It is found to vary with the temperature and concentration according to the same laws which regulate the pressure of a gas, and, further, the actual pressure produced is the same as that which would be exerted by the same substance (theoretically in the case of sugar) if it were in the state of gas at the same temperature and volume.

A large class of substances (such as sugar, urea, and most other organic substances) behave, therefore, in exactly the same way when dissolved in a solvent as they would in the gaseous state—as regards the relations between temperature, concentration, and pressure—only that what we understand by "pressure" in the gas state must be interpreted as "osmotic pressure" in the case of solutions.

By making use of Avogadro's hypothesis—that equal volumes of gases contain, at the same temperature and pressure, the same number of molecules—we can compare the molecular weights of gaseous elements or compounds by weighing equal volumes of them under the same conditions; and now by extending this hypothesis to substances dissolved in liquids we can compare their molecular weights in a similar way. It may be done in the latter case by measuring (directly or indirectly) the

osmotic pressure which is produced at a certain temperature and volume by a given weight of the substance.

If we apply this method to the determination of molecular weights of substances in water solutions, it is found that, although most of the organic (and some inorganic) compounds give perfectly normal results—(results, that is, which agree with vapour density determinations and with general chemical considerations)—most salts, acids, and bases give results which are apparently abnormal, the osmotic pressure produced being too high. A dilute solution of potassium chloride, for example, gives an osmotic pressure almost exactly double of that to be expected by the application of Avogadro's hypothesis. That is to say that one molecular weight of potassium chloride gives twice the osmotic pressure which one molecular weight of sugar (urea, &c.) gives under the same conditions.

It was suggested that this result might be explained by supposing that the salt is "hydrolysed" by the water—*i.e.*, that caustic potash and hydrochloric acid are produced. Since they would be formed in exactly equivalent quantities, it would not, of course, be possible to detect their presence by the ordinary tests. But such an explanation will not account for the fact that hydrochloric acid itself behaves "abnormally" also, giving about double the expected effect.

The theory of Arrhenius not only accounts for all these "abnormalities," but offers in addition a most elegant explanation of a large number of facts in connection with the behaviour of salts and other substances in solution, including the phenomena of electrolysis. This theory assumes that most salts, and the strong acids and bases, are largely if not entirely dissociated when dissolved in water (and in some other solvents) into constituent parts or "ions," and that these ions differ from the same substances, as we know them in the separated state, in that they are associated with enormous electric charges. A molecule of potassium chloride, for example, dissociates into an atom of potassium associated with a positive charge, and a chlorine atom with an equal and opposite negative charge. These charges are given up at the respective electrodes when the salt is electrolysed and the potassium and chlorine are obtained in their ordinary "neutral" state.

A revolutionary hypothesis of this kind was viewed, perhaps naturally, in the first instance with suspicion and dislike, and even at the present day it is not quite universally accepted, but the active opponents, at any rate those who have the courage of their opinions, are becoming daily few and far between. The application of this ionic dissociation hypothesis in explaining various well-known chemical phenomena is an extremely fascinating study and it is proposed to give various examples in illustration of the application at a future time. Just one may be mentioned here in conclusion.

A question which agitated the minds of chemists for a great number of years was of the following form: What happens when two different salts—say, sodium chloride and potassium nitrate—are mixed together in aqueous solution? Do they remain as they are or do they "change partners," forming sodium nitrate and potassium chloride? A large number of experiments were made with a view of throwing light upon this question, but in most cases the problem appeared to be incapable of solution. It was apparently of no use to attempt the isolation of the different salts since the equilibrium would be disturbed by their removal, and it seemed only admissible to employ methods which required no removal from or addition to the solution. Attempts were made, for example, to throw light upon the problem by observing the thermal, volume, or colour changes which occurred on mixing the solutions, and although a certain amount of information was gained by such methods, they were in most cases anything but conclusive.

This much-debated question then—which metal is united with which acid-radicle?—is (as a general case in dilute aqueous solutions) now at once disposed of by the ionic dissociation hypothesis, which gives the answer—No metal is united to any acid-radicle!

Wind-Driven Electricity Works.

By Dr. ALFRED GRADENWITZ.

PROFESSOR LATOUR, of the Askov Popular Academy (Denmark), has for some years been engaged on behalf of the Danish Government in investigating the problem of utilising wind power in connection with small electricity works. If, however, the dynamo be direct-coupled to the wind motor, the results obtained are unsatisfactory on account of the exceedingly variable speed of the wind. As pointed out in an address recently delivered by Professor Latour before the Copenhagen Technical and Hygienic Congress, he was met with difficulties in designing a suitable regulator for controlling the speed of the dynamo. At present, however, these difficulties appear to have been overcome, and an electricity central station near Askov has been worked with wind power for a year with satisfactory results.

The arrangement of a similar electricity works is represented diagrammatically in fig. 1. The regulating device itself is made up of two different parts. The mechanical regulating device is intended for maintaining at constant values the peripheric force transmitted to the belt disc of the dynamo. The two belt discs R R are mounted on a movable arm A, bearing a counterweight P. The resulting tension of the belt is thus kept constant, depending on the weight of the belt discs as well as on the counterweight P. The ratio of the resulting belt tension and the maximum peripheric force susceptible of being transmitted by the belts is, however, practically constant. The peripheric force transmitted by the wind motor to the belt disc R accordingly cannot exceed a given value, the torque of the dynamo remaining below a corresponding value. Any surplus energy developed by the wind motor is lost as heat with the friction of the belt. A constant torque of the dynamo axle will, however, correspond with a constant current intensity in the armature. In the case of the magnetising intensity employed, the load is in fact

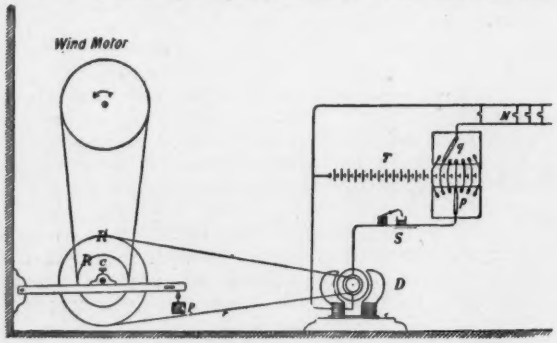


Fig. 1.

practically proportional to the speed, so that the intensity of the current may be regarded as constant. This is further demonstrated by the author's measurements.

The current from the dynamo is used to charge an accumulator battery represented diagrammatically in Fig. 1. The cut out switch F is closed, provided the current intensity be not inferior to its normal constant value. The dynamo D therefore works at a variable speed. In the case of the wind being so strong as to absorb part of the energy by the friction of the belt, the system will work in the following way: Assuming the accumulator battery to be nearly discharged and the crank of the cell controller to be adjusted for the total charge of the battery, the dynamo will run at a speed so high as to be quite sufficient to charge the battery with the normal current of a dynamo (*e.g.* 50 amp.). As the charge increases, the dynamo will automatically increase its speed and load so as to make the charging current constant. The cell-controller will have to be resorted to in charging in exceptional cases only—if, for instance, the charging and discharge of the battery takes place at the same time.

The electrical regulating device is situated in the interruptor S, being mainly an ordinary minimum current interruptor, disconnecting the dynamo as soon as the current decreases below the normal number of amperes. This arrangement is necessary to prevent the accumulator battery from being discharged through the dynamo when the strength of the wind is small. The interruptor, however, will automatically insert the current as soon as the wind again assumes a greater strength. To attain this result, the current interruptor is provided with a tension regulator, inserting the current as soon as the speed of the dynamo has sufficiently increased. In the case of variable strengths of the wind, the plant may thus accumulate any amount of wind available, the interruptor opening and closing the connections continually. On the switchboard there are in addition two ammeters and one voltmeter.

A small electricity works arranged in accordance with the foregoing principle has, as above mentioned, been in operation in Askov since the beginning of last autumn, supplying the inhabitants of the neighbouring communities with electric current. The constant normal current supplied by this installation is 60 amps. at tension of 220 volts. As a reserve, however, in cases of several days' calm weather, a petroleum motor had to be installed. The plant has so far given every satisfaction, requiring no superintendence worth speaking of. The man in charge of the machine was away for whole days, so that there was no supervision except in the morning and the evening. The capacity of the accumulator battery is sufficient to supply the maximum amount of energy required during 48 hours. As regards the economical side of the question: The first cost at Askov has been about 16,000 Kr. (a Kroner is about 1s. 1d.), out of which 3000 Kr. are set aside for the cost of petroleum motor. The electric current is supplied to consumers at the same price as in Copenhagen. The receipts for energy sold work out at about 2800 Kr., and the expenses at about 800 Kr. per year. There will thus remain 2000 Kr. for the amortisation of the plant, which is more than sufficient with a capital of 16,000 Kr. The price of energy could therefore be further diminished. In the case of small electricity works intended for the use of a limited number of houses, the petroleum motor may be replaced by a horse-driven contrivance. Moreover, in the case of the proprietor of the works being his own consumer, the consumption of current may be regulated according to the actual intensity of the wind; in the case of calm weather, there will for instance have to be no thrashing done, &c. The first cost will thus be considerably diminished; according to Prof. Latour's calculation, a plant suitable for a farm would be installed at a cost of 3000 to 4000 Kr.

The Works at Askov.

The Canals on Mars.

IN a communication to the Royal Astronomical Society on June 12, 1903, as reported in the *Observatory* for July, Mr. Maunder called in question the objective reality of the canals on Mars, explaining them away as psychological phenomena "due to the integration by the eye of markings far too small to be observed by the observer." He based his argument on the fact that copies of drawings of Mars without the canals, made by boys of from 12 to 15 years of age placed at various distances from the drawings, contained lines resembling canals amounting to five canals per head as a maximum at a distance of 25 feet, the diameter of the disk being about 6 inches. Unfortunately, the report gives us no information as to the closeness of coincidence of the lines with canals that have been actually observed, nor even as to the agreement between the lines drawn by different boys. It is difficult to see how the drawings to be copied could have contained actual Martian markings that were "far too small to be observed," whose integration produced lines in the positions in which canals have been observed; but if the drawings were not sufficiently accurate to show such markings, the lines must have been produced by markings peculiar to the several drawings, whose resemblance to anything on the planet is highly improbable. In drawing inferences from a comparison of artificial experiments with natural phenomena, it is certainly essential to the value of the results that the artificial and natural phenomena shall be substantially identical, and that the observations shall be made under practically the same conditions in both cases. On a later occasion, Mr. Maunder himself strenuously insists upon the necessity for a very close resemblance between the phenomena and between the conditions of observation in such cases. In criticising Mr. Lowell's application of the results of his experiments on the "visibility of fine lines" (the *Observatory* for September, 1903), Mr. Maunder says "there is actually no resemblance between the case of observing a wire in space and that of observing a line drawn on a surface"; nevertheless, he seems to find a sufficiently close resemblance between the observation of a flat picture (inaccurate, at best) with the naked eye in a

lighted room, and the observation of an illuminated ball surrounded by the blackness of night, seen through the mirage of its own atmosphere by means of a telescope. Those who draw conclusions from observations should be very careful in their reasoning, bearing in mind that induction, while a powerful instrument in the construction of theories, is absolutely useless in their proof or disproof. A theory of physical phenomena can be disproved only by showing that it leads by deductive reasoning to necessary conclusions that are inconsistent with observed facts. Mr. Maunder's theory may explain sufficiently well the lines on the copies of his drawings, but it no more suffices to disprove the objective reality of the canals observed on Mars than it does to prove that there are only five canals, as seen by his boys. The fact that an effect may be due to one cause, while it may certainly also be due to another, affords no presumption that it is due to the first rather than to the second, especially when the one explanation is based upon artificial experiments and the other is natural.

Mr. Maunder's argument assumes that the canals are seen as very faint lines, so faint that their existence is doubtful even to experienced observers; this may be true when they are observed through any but an exceptional atmosphere—and the atmosphere of Flagstaff is one of the exceptions. There, even under ordinary conditions, at the proper Martian season most of them are so easily and certainly seen that there is no reasonable doubt about them. Before Mr. Maunder ever discovered the psychical effect, Mr. Lowell was perfectly aware of it himself, and had studied it experimentally, which experiments he has continued to the present time, with the result that he finds a clear line of demarcation between confusion of real and imaginary up to a certain degree of definiteness of the real, and an instant consciousness of the difference between the two above that limit. The brain is not only conscious of the image, but directly conscious of reality as opposed to illusion. If Mr. Maunder's drawings had contained some canals for comparison with the imaginary lines, this difference would probably have been apparent.

The behaviour of the canals, their waxing and waning with the advance of the Martian seasons, is proof positive that they are not due to the integration by eye of *permanent* faint markings, and it is more difficult to account for the gradual and regular advance and retreat of such markings along the line of a canal than for the growth and decadence of the canal itself. Mr. Maunder's explanation seems to substitute an uncertain and almost impossible phenomenon for a very certain and probable one. From 8,500 determinations of the canals, Mr. Lowell has recently shown that they come into sight after the melting of the polar cap in times that are directly proportional to their distances from that cap measured in latitude. The enormous improbability of any such agreement in 375 drawings, the number he used, is so great as to run into the millions to one.

The logical conclusion of Mr. Maunder's argument, if valid, is that no faith is to be put in the reality of things seen, if anybody has ever been deceived in the appearance of such things. The scientific value of facts would then be liable to complete emasculation by the ignorance, carelessness, or malevolence of an observer. It is time an end should be put to the inquisitorial fashion of refusing credence to scientific discoveries until they shall have received the official recognition of the self-constituted authorities, especially when those authorities do not represent experts in the subject in question. That it is useless to continue the observation of planetary detail, because henceforth no reliance can be placed on what observers may tell us they have seen of such, can only be the doctrine of what may be called an "impressionist" school of science. If Mr. Maunder claims that his explanation is simply one mode of accounting for the appearance of the canals, he is practically throwing doubt upon their existence without taking the responsibility for it.

In the course of the discussion of Mr. Maunder's communication, Professor Newcomb said: "We all know how one improves by practice, and I think there is such a thing as improvement of the art of seeing things different from what they really are." This is a gratuitous slur upon scientific observation, to be justified only by the heat of a violent quarrel, and inexplicable under the present circumstances. Surely, Professor Newcomb cannot believe that the statements of an observer are any the less credible because he has had experience? No; these experiments show conclusively that observers must be trained to their work, that even descriptions of phenomena are of little value unless made by those who are experienced in observing phenomena of the kind described. The reports of such observers must be accepted as truly indicative of fact until they shall have been proved to be false, which can be done only by direct appeal to observation. WILLIAM EDWARD STORY.

Worcester, Mass., U.S.A., January 2, 1904.

[Mr. Story criticises the paper communicated by Mr. Evans and myself to the R.A.S. without first having done us the honour of reading it. This method has some disadvantages; one being that many of Mr. Story's remarks have no bearing at all on the questions with which we actually dealt. Want of space prevents my dealing with the details of Mr. Story's paper in the present number of "KNOWLEDGE," but if the subject sufficiently interests its readers I may return to it on a later occasion. For the present, it is sufficient to enter a strong protest against Mr. Story's quite uncalled-for attack upon Professor Newcomb. —E. WALTER MAUNDER.]

The Obelisk of Mount Pelee.

WE reproduce herewith a remarkable photograph taken by Mr. E. O. Hovey, for which we are indebted to our contemporary, the *Scientific American*. It represents one of the most peculiar and interesting phenomena of the recent eruptions of Mount Pelée. This was the growth of the tooth-like column of rock which arose out of the centre of the crater. It was first observed (by Professor Lacroix) in October, 1902, amid the dense smoke and steam overhanging the mountain. It was then estimated to be about 295 feet above the rim of the old crater. But subsequent observations proved it to be steadily growing, and after some months had attained a height of over 1000 feet. Professor Heilprin noted a growth of about 20 feet in four days.

Various explosions and movements of the earth altered the relative height of the obelisk. It rose and fell and large portions became detached. Bit by bit it then receded again, sinking as much as 150 feet during one night, but frequently rising again temporarily. This continued during many months, till finally it disappeared within the cone.

The cause of this curious apparition can but be vaguely surmised. It has been suggested that the vent of the volcano in olden days had become filled with solidified lava, and when the first outbreak occurred this whole mass was raised bodily up, as a cork is forced upward from a bottle.

The Obelisk of Mont Pelée.

XUM

The Face of the Sky for March.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the Sun rises at 6.48, and sets at 5.38; on the 31st he rises at 5.41, and sets at 6.29.

The vernal equinox occurs on the 21st, when the Sun enters the Sign of Aries at 1 a.m. and Spring commences.

Sunspots may frequently be observed, and for plotting their positions the following table may be used.

Date.	Axis inclined to W. from N. point.	Centre of disc, S of Sun's equator.
Mar. 1 ..	21° 48′	7° 14′
,, 11 ..	24° 0′	7° 12′
,, 21 ..	25° 31′	6° 57′
,, 31 ..	26° 21′	6° 30′

The Zodiacal light should be looked for in the west for a few hours after sunset.

THE MOON :—

Date.	Phases.	H. M.
Mar. 2 ..	○ Full Moon	2 48 a.m.
,, 9 ..	☾ Last Quarter	1 1 a.m.
,, 17 ..	● New Moon	5 39 a.m.
,, 24 ..	☽ First Quarter	9 37 p.m.
,, 31 ..	○ Full Moon	0 44 p.m.

The Moon is in perigee on the 1st and 29th and in apogee on the 14th.

Occultations.

The following are the more interesting occultations visible at Greenwich during convenient hours; it will be seen that on the 22nd the Moon is in the Hyades :—

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. point.	Reappearance. Angle from Vertex.	Moon's Age. d. h.
March 22	θ^1 Tauri	3·9	10.0 p.m.	131°	90°	10.41 p.m.	223°	184°	5 16
,, 22	75 Tauri	5·3	10.4 p.m.	30°	350°	10.35 p.m.	324°	285°	5 16
,, 22	D.M. + 15° 633 ..	6·5	10.4 p.m.	84°	44°	11.1 p.m.	270°	232°	5 16
,, 22	B.A.C. 1391 ..	4·9	10.46 p.m.	80°	41°	11.39 p.m.	274°	238°	5 17
,, 23	111 Tauri	5·2	10.6 p.m.	70°	30°	11.1 p.m.	293°	252°	6 16
,, 25	λ Geminorum ..	3·6	9 2 p.m.	108°	80°	10.11 p m.	272°	236°	8 15

THE PLANETS.—Mercury is in superior conjunction with the Sun on the 26th, and throughout the month is too near the Sun for observation.

Venus is an inconspicuous morning star during the month; also, as she only precedes sunrise by about an hour, she is badly placed for observation, and is becoming more unfavourably situated as she is approaching conjunction with the Sun.

Mars sets about 2 hours after the Sun on the 1st, and about 1½ hours on the 31st; on account of his small angular diameter, he is an insignificant object in the western sky shortly after sunset.

Jupiter is in conjunction with the Sun on the 27th, and therefore is only visible during the early part of the month after sunset.

Saturn is a morning star rising a little more than an hour before the sun.

Uranus rises after midnight and is situated rather low down in the sky near the star 4 Sagittarii.

Neptune, as will be seen on reference to the chart in the January number, is about midway and 10′ south of the line joining the stars η and μ Geminorum.

Telescopic Objects :—

Double Stars.—γ Leonis, X.^{h} 14^m, N. 20° 22′, mags. 2, 4; separation 3″·8. In steady air, the prime requisite for double star observations, this double may be well seen in a 3-in. telescope with an eyepiece magnifying about 30 to the inch of aperture, but on most nights one with a power of 40 is better.

The brighter component is of a bright orange tint, whilst the fainter is more yellow.

ι Leonis, XI.^{h} 19^m, N. 11° 5′, mags. 4½, 7½; separation 2″·2. A pretty double of different coloured stars the brighter being yellow, the other blue. This object requires a favourable night and a fairly high power on small telescopes.

α Leonis (*Regulus*) has a small attendant about 180″ distant, and of the 8·5 magnitude, and easily seen in a 3-inch telescope.

α Canum Venat. (*Cor Caroli*), XII.^{h} 52^m, N. 38° 50′, mags. 2·5, 6·5, separation 20″; easy double, can be seen with moderately low powers, even in 2-in. telescopes.

Meteor Showers :—

Date.	Radiant. R.A.	Radiant. Dec.	Radiant. Near to.	Characteristics.
	h. m.			
Mar. 1-4	11 4	+ 4°	τ Leonis	Slow; bright.
,, 14	16 40	+ 54°	μ Draconis	Swift.
,, 24	16 44	+ 58°	β Ursae	Swift.
,, 28	17 32	+ 62°	ζ Draconis	Rather swift.

THE STARS.—About the middle of the month at 9 p.m. the positions of the principal constellations are as follows :

ZENITH . No bright constellations in the zenith.

SOUTH . Cancer and Hydra on the meridian; Gemini high up, *Procyon* and *Sirius*, all a little to the W. Orion is to the S.W., and Leo (*Regulus*) to the S.E. high-up.

WEST . Taurus, Aries near setting, Auriga (*Capella*) high up. To the N.W. Perseus, also Andromeda low down.

EAST . Virgo (*Spica* rising), Bootes (*Arcturus*). To the N.E. Ursa Major high up, Corona, Hercules, and *Vega* low down.

NORTH . *Polaris;* to the right, Ursa Minor, Draco; below, Cygnus, Cepheus; to the left, Cassiopeia.

Minima of Algol may be observed on the 16th at 0 h. 7 m. a.m., 18th at 8.56 p.m., and 21st at 5.45 p.m.

XUM

A Photographic Atlas of the Moon.

VOLUME LI. of the Annals of the Harvard College Observatory is devoted to a photographic atlas of the Moon. This marks an epoch in selenography, not only because it is the first complete photographic atlas of the Moon yet published, but because every part of the Moon is represented under five different conditions of illumination—sunrise, morning, noon, evening, and sunset. This fivefold presentation is of the greatest importance to the selenographical observer, as the change in appearance of most of the lunar formations during the course of the lunar day is so great that a photograph taken at one time becomes almost unrecognisable if compared with the Moon at another. It constitutes a record in another particular, namely, that the entire series of photographs were taken within the short period of seven months. Yet a third feature of the atlas lies in that this was the first time that a long focus telescope has been successfully employed in this department of astronomy. Such telescopes have been employed with success upon the corona in recent eclipses, but their application to the systematic record of the Moon was a new departure.

This work is the result of one of those enterprises which the measureless energy of Prof. E. C. Pickering, and the corresponding munificence of the American public, have brought to completion within the last few years. An expedition under Prof. W. H. Pickering, who has had much experience of the superb observing conditions both of Arequipa and Arizona, was sent out from Harvard College to the Island of Jamaica, and reported so satisfactorily on the "seeing," that at the end of 1900 he took out there a photographic O.G. of 12-inches aperture, and 135 ft. 4 in. focal length. This was set up at Mandeville, 2080 feet above the sea level, and used as a fixed telescope in conjunction with a heliostat. The seeing did not prove to be quite equal to expectation, and a yet more serious drawback was experienced in the want of flatness of the heliostat mirror. In most cases, therefore, the aperture of the photographic telescope had to be diminished to 6 inches, and the exposures lengthened accordingly.

From the photographs taken by the expedition, 80 were selected, each 9 in., by 4 in., to form the complete lunar atlas, the Moon being divided for the purpose into sixteen different regions, each shown, as noted above, under five different conditions of illumination. The parallels and meridians were laid down on a photograph of the full Moon, taken on 1901, August 29, the positions derived by Franz from measures of five negatives of the full Moon taken at the Lick Observatory being taken as standards. Professor Franz's positions are undoubtedly the most accurate yet published, and Professor Pickering devotes the last chapter of his book to an inquiry as to whether the altitude of a lunar mountain can be deduced from the discordances between its apparent co-ordinates on the lunar surface, as measured under different conditions of libration. The result, however, is not very encouraging, the displacement to be measured being very nearly of the same order as the errors of observation, as Mr. S. A. Saunder has recently pointed out,* and a far more extensive series of measures than any yet published are required in order to satisfactorily solve the question of lunar altitudes. The third chapter is devoted to the consideration of lunar change; the cases of Eratosthenes, Plinius, and Pallas being lightly alluded to, whilst Linné, Plato, and Messier, with its companion Messier A, are treated with considerable detail. The enlargements of Plato and Messier, especially the former, by no means justify Professor Pickering's claim that "these are the first photographs published, so far as I am aware, showing the details of the floor so plainly that they may be clearly distinguished." They are certainly not equal to the photographs of Plato in MM. Loewy and Puiseux's Atlas. Another point on which Professor Pickering lays himself open to some criticism is the uncompromising way in which he habitually speaks of bright spots on the Moon being "snow," or "hoar frost," or "ice," whilst dark spots are often as unhesitatingly described as "patches of vegetation." While not wishing to ignore the very considerable amount of evidence which Professor Pickering has elsewhere presented in favour of these, his views, they cannot yet be regarded as more than mere opinions, and it is hardly legitimate for him to express himself as if they were altogether beyond challenge.

* *Observatory*, 1904, February, p. 96.

"Annals of the Astronomical Observatory of Harvard College," Vol. LI., a Photographic Atlas of the Moon, by William H. Pickering, Cambridge, Mass. Published by the Observatory, 1903.

Large v. Small Telescopes on Planets.

TO THE EDITORS OF "KNOWLEDGE."

SIRS,—I was much interested in Mr. A. Stanley Williams's letter in the current number of "KNOWLEDGE." No doubt there is reason in his suggestion. But to my mind there is a much stronger reason for the greater relative defining power of small telescopes when used on planets over their performance on double stars, which seems to be generally overlooked.

On double stars, I believe, the rule of 4·56 seconds of arc divided by the aperture is generally accepted as the limit of the telescope's dividing power, and this agrees very well with theory. But it only holds good when the objects to be separated are sufficiently bright to cause strong interference effects. Now the details on a planet are seen against a background nearly as bright, and except at the edges the contrast is very feeble, so interference phenomena are less appreciable. Therefore I hold that the 4·56 seconds-over-aperture rule does not apply. Mr. A. Stanley Williams, in his first paragraph, also seems to imply a doubt of ordinary rules holding for *large* areas, but I maintain that small telescopes will separate *details* on a planet very much closer than the above rule would allow. And so would, and sometimes does, a comparatively large aperture, but the magnification needed to tone down the light to utilize the larger aperture needs better atmospheric conditions, so that it is comparatively rarely that such apertures can be used with full effect. If we take 40 diameters to the inch of aperture as about the best ratio for viewing, say, Mars, one will on most nights find the seeing good enough to use the 120 needed by a 3-inch. But apply that rule to the 40-inch Yerkes, and how often can a power of 1600 be employed to advantage?

A few years ago I made some experiments to test the separating power of 1 inch of aperture directed to black spots on white paper. I found that 1 inch would divide dots separated not more than 1 second of arc, and lines 0·7 second apart; and that it would show a single black line 0·8 second in width, which was, of course, separating white areas divided by that amount only. I think these experiments, which can readily be repeated by anyone who wishes, show that when interference effects are negligible, one may expect a telescope to go far beyond the usually accepted limits. But if more were needed, Mr. and Mrs. Maunder have supplied it in the paper published last July in the B.A.A. Journal alluded to by Mr. Williams in his letter to "KNOWLEDGE." There they show that a black line on unglazed paper was seen *sharply defined* with the unaided eye under an angle of only 2·8 seconds of arc. Taking the pupil of the eye when fully dilated at the extreme of one quarter of an inch, this is equivalent to 0·7 second of arc for 1 inch, which agrees well with my own experiments detailed above, though I consider it much more noteworthy, as the retina is composed of hexagons that at the nodal point of the lens system of the eye subtend an angle of about 23 seconds of arc, and that such a coarse structure should show a line only 2·8 seconds wide as sharply defined seems to bear out what Mr. Maunder says in his last paragraph, that: "A straight line is that which gives the least total excitement in order to produce an appreciable impression, and *therefore* the smallest appreciable impression produces the effect of a straight line."

H. WAKE.

Whitehaven, January 11, 1904.

NOTES.

ASTRONOMICAL.

Mr. Denning's Observations of Mars in 1903.

IN the *Astronomische Nachrichten*, No. 3926, Mr. F. W. Denning gives the main results of his observation of Mars with a 10-inch reflector, in the Spring of 1903. The powers that he used ranged from 252 to 488, but the one most commonly employed was 312. He noted that occasionally there were decided changes in the visible appearance of certain markings, and these changes were obviously not due, either to uncertain seeing, or to the varying inclination of Mars, but, in the observer's opinion, to local vagaries in the Martian atmosphere. Thus, on May 6 and 7, he saw a white band dividing the canal Nilus, not seen on March 31 or April 2, and not shown on the charts. Again, on May 21, the northern region of the Syrtis Major was very dark, with a white cloud on its southern edge, but on May 23 and 24 the whole Syrtis Major was very faint, as if veiled by the cloud spreading northwards. As regards the "canals," Mr. Denning says: "A large number of irregular dusky streaks (canals), different in tone and direction, were observed. Some of these were very distinct, as, for example, Nilosyrtis, Protonilus, Indus, Ganges, Cerberus, Casius, &c., while others, as Phison, Euphrates, Gehon, were feeble or extremely faint and delicate. Many of them were knotted or strongly condensed in places, and particularly so at those points where either a junction or intersection of two of them occurred." Mr. Denning considers these streaks as certainly objective. He says that they were single, though in a few instances two of them were placed tolerably near together, running in approximately parallel directions. He is emphatic that the "prolific system of double canals delineated by some observers had no existence" during the period of observation, as far as his eye and telescope could determine.

Comparing these recent observations with those made in February, 1869, Mr. Denning deduces from 12,136 rotations of Mars, the value 24 h. 37 m. 22·7 s. for the rotation period.

* * *

The Double Canals of Mars.

Mr. Lowell, in Bulletin No. 5 of his Observatory, gives evidence against the hypothesis that the gemination of the Martian canals is an interference effect. If it were so, the width between the two components of a double canal should vary inversely as the aperture. To test this, Mr. Lowell observed a number of double canals with the full aperture of his telescope (24 inches), and then with that aperture reduced to 18, 12, and 6 inches. His measures of the drawings made under these several conditions showed that the apparent angular separation did not increase as the aperture was diminished; that the separation was invariable within the limits of observation for any particular canal, but differed for different canals, bearing no relation to the width of an interference pair of lines.

* * *

Mr. Lowell's Observations of Venus in 1903.

In Bulletin No. 6, Mr. Lowell classes the markings to be made out upon Venus under two heads. The first includes the collar round the south pole and the two spots on it, and the nicks inward from the terminator. Of these Mr. Lowell states he has always been certain, and "they alone are sufficient to show that the planet's rotation is an affair of about 225 days." The second class include the long shadings from the centre of the disc to the terminator, and of these, also, Mr. Lowell asserts "the objectiveness beyond the possibility of illusion." It will be seen that in this assertion Mr. Lowell is withdrawing his withdrawal of these markings which he published some eighteen months ago in the *Astronomische Nachrichten*, No. 3823. Mr. Lowell further adds that these streaks "bear no resemblance whatever to the 'canals' of Mars. They are faint streaks or spots. . . . They are not of even width, are not dark, and sharp cut. . . . Furthermore, they are of a much higher order of difficulty. Unless the conditions of visibility are such as to show an observer the 'canals' of Mars with ease and certainty, it were useless to attempt this much harder planet." But in 1897, Mr. Lowell wrote in the *Bulletin de la Société Astronomique de France*: "Les configurations ont toujours été très nettes, aussi nettes en vérité que celles de la Lune." In *Popular Astronomy* for December, 1896, he wrote: "The markings are both distinct and well defined; their contours standing out sharply against the lighter parts of the disc. . . . The seeing must be distinctly bad to have the more prominent among them not discernible." This would seem to show that the definition at Flagstaff, Arizona, has changed seriously for the worse in the last seven years, whilst a comparison of the drawings of Venus, given in the Bulletin, with those of Mars, such as in *Popular Astronomy* for April, 1895, would not lead to the conclusion that there was any essential difference between the streaks on the two planets.

* * *

Calcium and Hydrogen Flocculi.

A memoir of quite exceptional interest is given on the subject by Professor G. E. Hale and Mr. Ellerman in Volum. III., Part I., of the *Publications of the Yerkes Observatory* Its subject is the minuter study of the surface of the sun by means of the spectroheliograph. The first point brought out is the essentially granular structure of the calcium flocculi, the entire surface of the sun showing a fine mottling when photographed on the bright K-line. The next point is the study of these calcium clouds at different levels, the result of the examination bringing out in a striking manner the way in which the calcium bright clouds expand as they rise higher. The detection of the dark hydrogen flocculi is another feature, and the fact that they often correspond, though not precisely, with the bright calcium flocculi. Last of all the discovery of dark calcium flocculi was established, and the necessity for further work with spectroheliographs of much higher dispersion, and working upon larger images of the sun, is insisted upon. The memoir is illustrated by fifteen extremely fine photographic plates.

* * *

The Nebulae.

The *Nineteenth Century and After* for February contains an article on "The Nebulæ," by the Rev. Edmund Ledger Gresham Lecturer on Astronomy, which summarises with admirable clearness and precision, the state of our present knowledge respecting these mysterious objects, and the connection with them of the stars.

ZOOLOGICAL.

AT the meeting of the Geological Society held on January 20 Dr. A. Smith Woodward, of the British Museum, definitely determined the systematic position of the cretaceous fishes of the genus *Ptychodus*, whose large, quadrangular, ridged crushing teeth are such familiar objects to collectors in the chalk-pits of the south-east of England. It has long been known that *Ptychodus* was an elasmobranch fish, and Dr. Woodward himself had some years ago pointed out the probability of its being a ray, or skate, rather than a shark. The truth of this conclusion is fully demonstrated by a specimen of the jaw cartilages recently discovered near Lewes, which serve to show that these fishes were allied to both the eagle-rays and the sting-rays, and probably, therefore, the ancestral type of both. A photograph was shown at the meeting of a splendid American specimen of the dentition of *Ptychodus*, with the teeth in their natural position, forming longitudinal rows.

* * *

Fossil Birds.

Certain fossil bird remains were discussed by Dr. C. W. Andrews at the meeting of the Zoological Society held on

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January 19. From Madagascar the speaker described a pelvis and thigh-bone of an ostrich-like bird closely allied to the extinct roc (*Æpyornis*) of that island, but regarded as generically distinct, under the name of *Mullerornis*. Much greater interest attached to a fragment of another bird of the same group from the Eocene strata of the Fayum district of Egypt, for which the name *Eremornis* was suggested. Possibly the discovery of this specimen might serve to demonstrate that all the ratite birds have a common ancestry, and are not, as some suppose, isolated members of a number of distinct groups which have lost the power of flight independently of one another.

* * *

A Sub-Species of Giraffe.

At the meeting of the above-named Society, on February 2, the local sub-species of giraffe formed the subject of a communication by Mr. Lydekker. It was shown that, as in the case of the boute-quagga, or Burchell's zebra, a number of local forms readily distinguishable by their colour and markings, and (in the case of the giraffe) to some extent also by differences in the skull, are recognisable as we proceed from north to south down the eastern side of the Continent. In both instances it seems advisable to regard their local forms as races, or sub-species, rather than species. The northern forms are characterised by the presence of a large frontal horn and the white legs; but, as we proceed south, the median horn gradually becomes reduced to a mere boss, while the legs acquire spots right down to the hoofs. In the latter respect giraffes show a modification, exactly the opposite of that presented by the boute-quaggas, in which the legs lose their stripes as we proceed south. Some of the East African giraffes are very remarkable, developing, in certain instances, rudimentary horns on the occiput, or over one eye, or displaying a marked sexual difference in colour. A race from the south of Lada was named in honour of Major Powell-Cotton, the celebrated explorer, and a second, from the Northern Transvaal, after Mr. Rowland Ward, of Piccadilly.

* * *

Cachalot Whales.

In the *Field* of January 3 reference is made to the occurrence of quite a number of sperm-whales, or cachalots, in the North Sea and North Atlantic; no less than seven adult bulls being definitely known to have been captured. As a rule, these whales are confined to tropical and subtropical seas, only a few old bulls occasionally straggling northwards. In the present instance a whole herd must have thus wandered out of the proper latitude. Recently Sir William Turner has recorded the capture of an old bull in the Shetlands in 1901, also mentioning that a herd was seen off the Faroes in 1899; while in the *Field* of January 30 Mr. T. Southwell refers to accounts of herds of these whales straying northwards in 1723 and 1752-53.

* * *

The Primeval Instincts.

A discussion has been going on in the columns of the *Field* as to the reason why horses when getting up from the recumbent posture raise themselves first on the fore-limbs while ruminants do so on the hind-limbs. It appears that tapirs, apparently rhinoceroses, and swine follow the horse-fashion; an association which demonstrates that the movement is not dependent on the presence of a third trochanter on the femur of the Perissodactyla (horses, tapirs, and rhinoceroses). One writer has suggested that the ruminants' mode of rising is for the purpose of bringing the horns into action for defence as soon as possible, but against this is the case of the rhinoceroses. Possibly the raising of the hind-legs first may be connected with the function of rumination and the complex form of stomach correlated therewith. One correspondent stated, however, that an ass rises like a ruminant, which, if true, upsets all theories.

* * *

New Mammals.

An instance of the pace at which American naturalists are increasing zoological nomenclature is afforded by a paper by Dr. D. G. Elliot recently published by the Field Columbian Museum of Chicago, in which no less than twenty-seven apparently new forms of mammals are described. Hitherto there has been supposed to be only a single species of glutton, or wolverine, but the author describes the Alaskan representative of that animal as new, under the name of *gulo luteus*. A new race of bighorn sheep (*Ovis canadensis cremnobates*) is also recorded from the San Pedro Martir Mountains of Lower California and Mexico.

* * *

Bird Migration.

Mr. W. Eagle Clarke, who is well known as an authority on the subject of the migration of birds, made a month's stay last autumn on the Kentish Knock Lightship, and the results of his valuable observations are detailed by him in the *Ibis*. It required a good deal of courage to brave the hardships and discomforts inseparable with life on a lightship 21 miles from the nearest point of land, but Mr. Clarke was so engrossed with watching the birds which passed the ship by day and were lured to its light by night that he seems to have hardly noticed the discomforts involved. Apart from the valuable details regarding the various species of birds migrating and the directions in which they were travelling, as well as many other points which we have not space here to discuss, Mr. Clarke makes some remarks of high importance with regard to some of the phenomena of general interest connected with bird migration. As an explanation of how birds find their way during migration it has been suggested that the great height at which they fly enables them to see enormous distances. But Mr. Clarke, while not denying that birds sometimes do migrate at great elevations, disposes of the theory that they depend on this means for finding their way. During all the time he was on the Kentish Knock Lightship the migrants of every species flew close to the water. Yet whatever the weather or state of the sea they kept a straight and apparently unerring course for the coast 21 miles distant. Mr. Clarke reaches the conclusion from this and other facts that birds are endowed with a sense of direction. Such a statement is, of course, in no way an explanation of the mystery as to how birds find their way, since we have no conception of the nature or workings of such a "sense." But the evidence that they do not find their way by sight is of the utmost importance. Those interested in bird-migration should not fail to read Mr. Clarke's latest and very valuable contribution to our knowledge of the subject.

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Burrowing Fishes.

In *Fasciculi Malayensis*, a publication devoted to the description of the results of a recent expedition to the Malay Peninsula, a writer records a remarkable habit on a part of one species of the mud-haunting fishes of the genus *Periophthalmus*. These fishes make burrows in the mud, and retain a pool above the same, by preventing the water from flowing away during low tide by means of a circular well built by themselves.

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One of the most remarkable palæontological discoveries is recorded from North America, where an Eocene lemur is believed to be allied to the curious aye-aye (*Chiromys*) of Madagascar. The extinct form is named *Parachiromys*.

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Papers Read.

In addition to those already mentioned in special paragraphs, reference may be made to the following zoological papers read at various scientific societies. At the Linnæan on December 17, Mr. H. J. Fleure discussed the origin and evolution of the gastropod molluscs known as *Docoglossa*, of which the limpet is a familiar example. At the same Society on January 21, the Rev. T. R. R. Stebbing read a paper on the Crustacea obtained during surface dredging from H.M.S. *Research*, in the Bay of Biscay, during the summer of 1900. On January 19, before the Zoological Society, Mr. O. Thomas described a new subspecies of the aoul (*Gazella Sœmmeringi*) from North-East Africa. At the same time Mr. G. A. K. Marshall presented a monograph of the beetles of the genus *Hipporhinus*. Dr. W. Kidd called attention to the importance of the arrangement of the hair and the distribution of hair whorls in the classification of mammals. Dr. W. G. Ridewood described the skull of the giraffe, as seen in vertical transverse sections; and Mr. F. E. Beddard read a note on the brain of two lemurs. At the meeting of the same Society on February 2, in addition to Mr. Lydekker's paper on giraffes, a communication was received from Mr. O. Thomas on a collection of mammals from Namaqualand, including a new species of strand-mole

(*Bathyergus*); and Mr. Beddard discoursed on the arteries of the base of the brain in certain mammals. Two papers by Mr. G. A. Boulenger were also taken at the same meeting, the one dealing with three new fishes from the Niger, and the other with the type specimen of the West African cat-fish known as *Clarias læviceps*. At the meeting of the same Society, held on February 16, Mr. C. Crossland presented the third instalment of a dissertation on the marine fauna of Zanzibar and British East Africa, dealing in this instance with the polychætous annelids: and also a second paper describing a collection of the same group of organisms from the Malay Peninsula. The third paper, by Sir C. Eliot, dealt with certain nudibranchiate molluscs from Zanzibar and British East Africa.

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A New Gazelle from the White Nile.

Considerable interest attaches to the description by the Hon. Walter Rothschild, in *Nevitater Zoologicæ*, of a fine new species of gazelle from the banks of the White Nile, which it is proposed to call *Gazella albonotata*.

BOTANICAL.

HERR LINDEMUTH, of Berlin, has published in *Gartenflora*, 1903, Heft 18 and 23, the results of his experiments on the propagation of plants by means of their leaves. Horticulturists have long been accustomed to use this means of propagation in a few plants, notably in the *Gloxinia* and certain Crassulaceæ, among which *Bryophyllum calycinum* is a well-known example. It was, however, probably not suspected that the leaves of so many plants could be made to produce roots. In his first communication Herr Lindemuth gives the names of twenty-eight species, of nearly as many different genera, in which his experiments have been successful. These include such plants as the Foxglove (*Digitalis purpurea*), the Musk (*Mimulus moschatus*), the Tomato, and the Vine. The leaves of thirteen species, including the Potato, Monkshood (*Aconitum Napellus*), and the common bedding Geranium (*Pelargonium zonale*) refused to root at all. Usually the roots were produced quickly—in the Vine in sixteen days, in *Veronica* in seven days, and in the African Marigold in eight days—but the amount of time required, and, indeed, success at all, was shown to depend very much on the season when the experiments were made. Thus, in the Vine, roots were developed in sixteen days in August; but complete failure resulted in September, when the leaves perished. In his second communication, the author records success with thirty-four additional species, including three of those with which he had met with failure before. The results so far obtained show that few of the leaves thus experimented on will form buds, only five having done so. In the case of a species of *Citrus*, the leaves rooted and persisted for months and even years without any further development.—S. A. S.

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Recent Research in Agriculture.

Mr. HALL, the Director of the Rothamsted Experimental Farm, lecturing at the Royal Institution on "Recent Research in Agriculture," dealt with the growth of wheat, still an important crop in Great Britain, despite the fact that the area under wheat has shrunk from more than four million acres in 1860 to less than 1,800,000 at the present time, and that we only now produced about seven million quarters, and had to import more than 25 million quarters. The English yield averaged, however, more than 31 bushels per acre, considerably greater than that of any other country, and double or treble that of the chief countries who send us wheat. The lecturer then showed, by examples drawn from the Rothamsted experiments, that the production of wheat could be greatly raised by the use of manures, but that this process soon ceased to be profitable—"high farming is no cure for low prices." A further difficulty to be faced by the English wheat grower is the comparatively low price of this product, the best Manitoba or Russian or Argentine wheat realising 20 to 25 per cent. more than the best English wheat. This difference of price is due to the greater "strength" of the flour made from such foreign wheats, meaning by "strength" the capacity to make more and larger loaves for equal weights of flour used. The lecturer illustrated the point by exhibiting loaves baked from equal weights of English and American flour, the American one being decidedly larger and more attractive in appearance. For some time the lecturer had been concerned with an enquiry initiated by the National Association of Millers, and helped by the Board of Agriculture, as to the conditions which brought about "strength" in flour, and how English wheat could be improved in this respect. Climate being one of the chief factors, the lecturer contrasted the English climate with that of the Hungarian Plain and of the North West. The development of wheat, the rate of formation of the grain, and the migration of the nitrogenous constituents into the grain was then studied at Rothamsted, and compared with similar results obtained in Hungary; all tending to show that strength is associated with a short period of ripening. Strength is dependent on the nitrogenous content of the wheat, but the attempts to correlate it more exactly with total nitrogen, with gluten, or with the ratio between gliadin and glutenin, as certain French and American chemists have done, fail to show consistent results. Climate is not, however, everything in causing strength, for even among English wheats some are much stronger than others. Certain foreign varieties also when introduced into this country retain to a very considerable degree their strength, at any rate for three or four years. However, they generally give crops considerably below the English standard, though for late spring sowing some of the best, like No. 1 Hard Manitoba, are probably equal to any Englsh varieties. As "strength" is a quality inherent in the variety, it is capable of improvement by cross-breeding and selection, and a considerable amount of very promising work has already been done in this direction, the disideratum being increased strength with the cropping powers of the best English varieties. The lecturer exhibited various loaves made from English and foreign varieties of wheat grown in this country to illustrate the foregoing points.

PHYSICAL.

Photography in Natural Colours.

THE principal novelty of a process for obtaining photographs with natural colours, just brought out in Berlin, is the fact that any ordinary negative may be made to give chromatic prints with the original colours. Suppose a view of a landscape to be taken with an ordinary plate; the sky being blue, will throw on the plate the most efficient light, so as to produce on the negative the thickest dark layers. The leaves of the trees, on the other hand, will produce less intense effects, and still less will be the action of the red portions. Now the inventor, Oberleutnant von Slawik, an Austrian, has designed a special kind of pigment paper, bearing a number of superposed dye-stuff layers; underneath there is a red layer, in the middle a green, and above a blue layer. Now the most strongly covered portions of the negative—representing the sky—will evidently be the least translucent, the light actually penetrating being able to act only on the upper blue layer, rendering insoluble only the chromium jelly constituting this layer. The thinnest portion of the negative, corresponding for instance to a red wall, will in printing transmit the greatest amount of light; all three pigment layers thus being struck by the light will become insoluble down to the lowest red layer. The green leaves will, as above shown, give rise to a covering of the plate of medium intensity, a medium amount of light penetrating the paper at the corresponding portions of the plate, this amount of light being just sufficient to render insoluble the two upper blue and green strata, whereas the lowest layer will remain unaltered.

After printing, the paper, as usual, is pressed on another sheet of paper, when the coloured layers are transferred from one sheet to the other, the printing being afterwards "developed" with warm water, in the way usual in pigment printing

After the transferring the low layers of the original paper will in the new paper be uppermost. The warm water will, therefore, be able to rinse off any jelly layers which have not become insoluble by the effect of light. On the portions corresponding to the sky, the green and red layers which are not struck by light will be removed, the blue layer only remaining. In the red wall, where the light as above shown has penetrated all the existing layers down to the lowest red layer, which, after the transferring is above all the remaining, no alteration will be produced, while in the portions corresponding to the green leaves only the red layer, which now covers the green colour, will be washed off by the water, when the green colour becomes visible, covering the blue layer lying underneath. In practice, it has been found advisable to use a larger number of coloured layers instead of those corresponding to the three fundamental colours only, so as to produce all the shades required; up to 14 pigments are thus used. The above process has been developed in the laboratory of Dr. Ad. Hesekiel and Co., Berlin. As a matter of course, any old negatives taken at any time may be made to reproduce the true colours of the original.—A. G.

The Blondlot or N-Rays

IN view of the interest which has been imparted to M. Blondlot's N-rays by the investigations of Professor Charpentier, and also by the doubts which have been thrown on the real existence of the rays, we have thought that it might be interesting to collect the ascertained facts and observations concerning these rays. For this summary we are chiefly indebted to a series of articles contributed by Mons. Laverune to *Cosmos*.

The N-rays were discovered by M. Blondlot, of Nancy, while studying Rontgen rays. By endeavouring to pass rays through a sheet of aluminium, he separated quite a new group of radiations. The rays he found were such as to penetrate aluminium, black paper, or wood. They could be polarised and might be deflected or diffused, but they produced neither fluorescence nor photographic action. They were invisible, gave no sensation of light, but augmented the brilliancy of an electric spark.

It is this property which enables us to detect the rays. They are incapable of exciting phosphorescence in bodies which can acquire this property from the action of light; but when such a body, sulphuret of calcium for instance, has first been rendered phosphorescent by exposure to light, then if submitted to the action of these rays, especially if they are focussed by a quartz lens, one can see the brightness of the phosphorescense perceptibly increase. In the same way if one directs them on to a little flame of gas at the end of a metal tube pierced by a very minute orifice this flame, entirely blue, becomes whiter and more luminous. We are now furnished with these means of detecting the presence of these radiations. M. Blondlot, struck with certain analogies that they present with the radiations discovered by Professor Rubens in the emissions of the Auer Burner, asked himself if the N-rays were not identical. An Auer burner was enclosed in a kind of lantern of sheet iron closed at all points, with the exception of the openings for the escape of air and the gas from combustion, and so arranged as to prevent the passage of any light. A rectangular window opened in the iron at the light of the incandescent mantle was closed by an aluminium sheet 1 mm. in thickness. The chimney of the Auer burner is of sheet-iron. A slit was opened opposite the mantle, so that the luminous rays which emanate from it might be directed on to the aluminium sheet. Outside the lantern in front of the aluminium sheet was placed a biconvex lens of quartz, and behind it an exciter giving little sparks. It was ascertained that the spark is of greater or less clearness according to the distance at which it is placed from the slit. M. Blondlot proved the existence of four distinct kinds of radiations. When one directs a pencil of these rays either on to an electric spark, or on to a little flame, or a phosphorescent substance previously exposed to light, one can see the light emitted by these different sources increase in brilliancy.

The greater number of artificial sources of light and heat emit N-rays. The sun emits them, as the following experiment shows: A completely dark and closed room has a window exposed to the sun, this window is shut by inside oak shutters, 15 millimetres in thickness. Behind one of these shutters, at a distance of 1 metre, is placed a tube of fine glass, containing a phosphorescent substance of sulphuret of calcium for example, previously slightly insulated. If now in the trajectory of the sun's rays, which are supposed to reach the tube through the wood, there is interposed a piece of lead, or even simply the hand, even at a considerable distance from the tube, the brightness of the phosphorescence diminishes. If one takes away the obstacle it re-appears. The interposition between the shutter and the tube of several sheets of aluminium, of cardboard, of a piece of oak three centimetres thick, does not prevent the phenomenon from taking place. All possibility of heat radiation, properly so called, is therefore excluded from hypothesis.

Certain substances appear to have the power of storing up N-rays, and afterwards emitting them; but the rays appear to penetrate a metallic mass, in this sense, very slowly. Thus, if one side of a sheet of lead two millimetres thick has been exposed to N-rays for some minutes, that side only has become active. An exposure of several hours is necessary for the activity to reach the other side. Aluminium wood, dry or moist paper, paraffin have not the property of storing up N-rays. Sulphuret of calcium has it. Having enclosed a dozen grammes of this sulphuret in an envelope, and then having exposed the envelope to N-rays, M. Blandlot proved that its neighbourhood sufficed to reinforce the phosphorescence of a little lamp of sulphuret previously exposed to light. This property explains why the increase of the phosphorescence of the action of N-rays takes an appreciable time both to be produced and to disappear. Owing, in fact, to the storing up of the N-rays, the different portions of a lump of sulphuret mutually augment their phosphorescence, the storing up is progressive, the store is not instantly exhausted, so that when one directs the N-rays on to the phosphorescent sulphuret their effect slowly increases, and when they are suppressed their effect is only gradually extinguished. Following on the experiments made by M. Charpentier on the emission of N-rays, experiments to which we shall return, M. Blondlot conceived the idea that certain bodies might acquire the property of emitting rays from compression. He proved that pieces of wood, of glass, of indiarubber compressed by means of a carpenter's vice, become, during the compression, sources of N-rays.

Bodies which are themselves in a state of forced equilibrium, or molecular strain, as tempered steel or hammered brass, are spontaneous and permanent sources of N-rays. One can show it by means of the phosphorescent screen, and by another indirect method—that of the increased action of a pencil of light upon the eye when it is accompanied by N-rays.

The shutters of the laboratory are almost closed, and the face of the clock fixed to the wall sufficiently lighted for it to appear faintly as an indeterminate grey stain upon the wall at a distance of four yards. If the observer, without changing his place, directs towards his eyes the N-rays emitted by a brick or pebble, previously insulated, he sees the face whiten, distinguishes clearly its circular shape, and may even succeed in seeing the hands. When the N-rays are suppressed the face again darkens. Neither the production nor the cessation of the phenomenon are instantaneous.

As in these experiments the luminous object is placed very far from the source of the N-rays, and as besides, in order that the experiment should succeed, it is necessary that the rays should be directed not towards this object, but towards the eye, it follows that there is no question here of an increase of the emission from a luminous body under the influence of N-rays, but rather of the reinforcement of the action received by the eye, which is due to the N-rays which are joined to the rays of light. One can replace the brick by a sheet of tempered steel.

The energy that the emission of N-rays represents is probably borrowed from the potential energy which corresponds to the forced state of tempered steel. This expenditure is doubtless extremely feeble, since the effects of the N-rays themselves are so, and thus explains the apparently illimitable duration of the emission. A sheet of iron that is bent so as to take a permanent deformation emits N-rays, but

the emission ceases at the end of some minutes. A block of aluminium struck with a hammer does the same, but the duration of emission is much shorter. In these two cases the molecular constraint is temporary, and the emission of N-rays also. Torsion produces analogous results to compression.

Professor A. Charpentier's investigations of N-rays are second in importance only to those of their discoverer. He sought for the radiation of N-rays chiefly with the aid of phosphorescent screens of sulphuret of calcium, but found that screens coated with platino-cyanide of barium, whose fluorescent intensity he regulated, with the aid of a salt of radium, covered with black paper, would give more satisfactory results. By these two processes of research, he discovered that N-rays can have several other origins than those of the sources of light indicated by M. Blondlot. He recognised that the little phosphorescent or fluorescent object increased in luminous intensity, when it was brought near the body. Moreover this augmentation is more considerable in the neighbourhood of a muscle, and so much the greater as the muscle is strongly contracted. The same thing occurs in the neighbourhood of a nerve, or of a nervous centre, where the effect increases with the degree of activity of the nerve or of the nerve centre. By this means, in spite of the delicacy of the observation, one can recognise the presence of a superficial nerve, and follow it. These effects are not only observed by contact with the skin, they are perceptible at a distance. They are transmitted through substances transparent to N-rays (aluminium, paper, glass, &c.), and stopped by the interposition of substances, which are opaque to the same rays, lead (incompletely) or wet paper. They are not due to an increase of temperature in the neighbourhood of the skin, for they continue if several sheets of aluminium are interposed, or of cardboard separated by layers of air and forming a calorific screen. These rays are reflected and refracted like N-rays.

M. Charpentier has produced foci, manifested by the maxima of brightening by the aid of convergent glass lenses. The position of these foci, or maxima, although difficult to exactly determine, permitted recognition of the fact that the indication of refraction of rays emitted by the body was at least of the class and size of that determined by M. Blondlot for N-rays. It might be asked if the human body really emitted these rays, or if it only stored them up during the day or in the light, in the same way as the insulated bodies studied by M. Blondlot. After a sojourn of nine hours in complete darkness the phenomena were the same, and were still more easy of observation, because of the more perfect adaptation of the eye. The nerves and nervous centres, when they are the seat of an excitation, emit the rays in greater abundance. Charpentier has been able to determine the area of the heart; he has also been able to follow the trajectory of a superficial nerve; he has been able to recognise the topography by certain psychomotor zones in the cerebral surface. He has seen in fact, that if the subject of the experiment happens to speak, the detective screen, when advanced at the same moment towards the region of the cranium which corresponds to the zone of articulate language, at the level of the left frontal convolutions, is more brightly illumined than when he kept silence. The researches of Charpentier suggest that the radiations called N-rays are not all alike, but must in reality result from an assemblage of radiations of attributes as diverse as their origin some being emitted especially by the elements of the nervous tissues, and others by those of the muscular tissues. This theory is in accord with the physical observations of M. Bondlot. Experiments already dating from several months have in fact shown to this eminent physician that the bundles of N-rays broken up by a prism spread themselves into a sort of spectrum, which establishes beyond proof that all the broken rays—rays whose wave length, incomparably smaller than that of light rays—are unequally refrangible, and consequently possess each individual attributes. The wave length has been recently determined as not greater than 8 micro-millimetres—about the one millionth of a centimetre.

WE have received from Mr. H. J. Glaisher a copy of his March catalogue of "remainders," which we notice contains many valuable and useful volumes in zoology, botany, and the various other branches of natural and applied science.

The Super-Solid.

Hints towards a Conception of the 4th Dimension.

By C. E. BENHAM.

SPACE, as we conceive it, comprises length, breadth, and thickness, and it is hardly possible to imagine a fourth direction which is none of these. Further than that, our minds are so constituted that we seem to see that such a new direction could not be. When we have traversed any material substance longitudinally, and across, and up and down we appear to have traversed it exhaustively. There is no direction which is not one of these—or, as we might say, there could be no direction which is not one of these three or intermediate between them. This is so as to all material substance, and that it is so as to space in the abstract we feel equally convinced, because by space we mean nothing else but the length, breadth, and thickness which matter occupies or might occupy.

Yet, as every appreciative reader of Abbott's Flatland knows, there is more to be said on this matter. Suppose a race of beings whose senses were such that they had never had any reason to suspect thickness as a property of matter, but were only conscious of length and breadth, would it not appear to them that length and breadth filled all space, and that a third dimension was as impossible as it was inconceivable?

Such a race of beings, conscious only of two dimensions, is indeed not unimaginable. Some have even theorised that a sightless snail, crawling from surface to surface, has no concept of any third dimension, but exception might be taken to the blind snail as an example of a Flatlander, for possibly his body might occasionally lap the two sides of a flat stone as he curled over the edge of it. But one can imagine a blind snail-like being of such minuteness that the smallest particles of all other matter were much larger than its body. Such a creature, though three-dimensional itself, might well have no suspicion of any dimension beyond infinite surface. It matters not in the least whether no such snail exists. The fact remains that such existence is imaginable, and that it is evident that in such a state of existence scepticism as to the possibility of a third dimension of matter would be just as deep and instinctive as ours is against the possibility of a fourth.

We may conclude, then, that our limiting of the number of dimensions possible to space to three, is due to the circumstance that as we are constituted our senses cannot conceive a fourth. To say that, therefore, a fourth does not or cannot exist is to go further than we have warrant for. But though we cannot see or by any sense perceive a fourth dimension in addition to length, breadth, and thickness, we may be able reasonably to infer something about the character of such a hypothetical dimension, assuming, for the sake of discussion, that it may exist.

Some of the properties of a fourth-dimensional "super-solid" have been dealt with by more than one writer, notably by Spottiswoode, in his Presidential Address to the British Association at Dublin in 1878, and by Howard Hinton, in his interesting little volume on the subject of the Fourth Dimension.

A suggestion is often met with that Time is the fourth dimension of matter. Time may indeed be looked upon as a symbol of the fourth dimension—an illustration of the possibility of a direction which is neither up nor down, nor from side to side, for in time are there not for-

ward and backward directions which are neither of these, and which are extraspatial? But, except in this figurative sense, the introduction of time as a solution of the fourth-dimensional question is merely a confusion of the problem. Time does not belong to the same category of thought with length, breadth, and thickness. Point, line, surface, solid—these follow each other as a development in orderly sequence, but point, line, surface, solid, time—these terminate in a meaningless *non sequitur*.

Again, we may say that as a point is to a line so is a line to a surface, or we may say that as a line is to a surface so is a surface to a solid. This is intelligible, but to add, as a surface is to a solid, so is a solid to time, or to any portion of time, is unintelligible nonsense. Moreover, the concept of time does not strike one as being (as the conception of a sphere would be) impossible to Abbott's Flatlanders, whereas it ought to seem even more so if it were actually two dimensions ahead of them. Indeed, it ought to seem impossible to ourselves, unless we are fourth dimensional beings.

But without confusing the issue by incongruously introducing the concept of Time into the province of Space, let us see what may reasonably be conjectured as to fourth-dimensional existence.

The elements of the inquiry are strikingly illustrated by Hinton in some such way as the following:—

Two points joined = One line.
Two lines joined = One square.
Two squares joined = One cube.
Two cubes joined = One (?).

The series may be set out in this way:—

	No. of Dimensions.	Terminal Points.	Joining Lines.
Point .	0	1	0
Line —	1	2	1
Square □	2	4	2
Cube ⧈	3	8	4
Super-cube	4	16	8

Before we proceed to deal with the perspective representation of the last in this series of figures, the super-cube, it will be well to put ourselves back in imagination into Abbott's Flatland, and to consider what would be our Flatlander's impression of the perspective representation of the cube. "Here is no third dimension," he would say; "here are but two squares with lines joining them." To us, who are accustomed mentally to connect such a figure with the similar retinal image which a solid cube forms in our eye, the concept of a third dimension is conveyed by association of ideas, but with the Flatlander no such association of ideas would exist, because he would have had no experience of "thickness," and the figure would remain for him a Flatland one—two squares joined by four lines. Similarly, a full-face view of a cube would of course be to him simply a square, and in fact cannot be otherwise rendered on a flat surface.

Now our relations to fourth-dimensional diagrams must be analogous. It is possible that we might make a pictorial rendering of a super-cube on paper, which to a being with senses capable of appreciating fourth-dimensional space would be suggestive of a fourth-dimensional super-solid, but to us, with no association of ideas to aid us, the figure must not be expected to afford a representation of more than three-dimensional form. The figure for the super-cube would, in fact, be like this:—

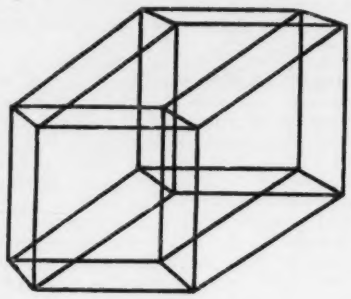


Fig. 1.

As the drawing of a cube to a Flatlander would seem to be only two squares on the same surface united by lines also on that surface, so to us the above figure can at most only convey the idea of two cubes united by lines or perhaps by surfaces. We shall see this better if we draw the figure in perspective stereoscopically and examine the result in the stereoscope, when the two drawings will blend into one apparent solid. Here is such a stereoscopic diagram of the super-cube:—

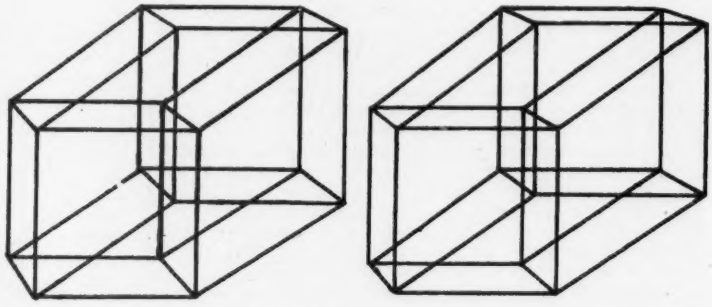


Fig. 2.

This slide, when seen in the stereoscope, shows us a peculiar looking figure, apparently three-dimensional. Now just as the perspective drawing of the cube suggests one three-dimensional figure to us but to the Flatlander a pair of united squares, so the above stereogram represents a pair of united solids to us, but to beings with fourth-dimensional perception it might convey the notion of one super-solid.

It becomes evident, therefore, that while our senses are (as at present) limited to three dimensions, we cannot expect in the way thus far indicated to get any nearer to a concept of the super-cube.

Yet there remains an experiment which carries us just a step further, and brings us to the very verge of a solution of our problem.

Before we make this experiment it will again elucidate the matter if once more we imagine ourselves for the moment in Flatland. There the drawing of a cube directly facing us would, as we have seen, be only one square, or more strictly one square exactly behind another. To the Flatlander, who does not know what "behind" means, it would be as though the two squares occupied the same space at the same time.

Now the analogy from this is obvious, for in the same way under similar circumstances the super-cube of fourth-

dimensional perception would to our perception seem like two cubes occupying the same space at the same time. They would really represent two separated cubes, but separated in a direction neither up nor down, nor sideways, nor cross-ways—in a direction of which we, with our three-dimensional conceptions, have no cognizance, just as the Flatlander had no cognizance of the meaning of a square being "behind" another square. The perspective view of the cube when not seen full face would show the Flatlander the two squares only partially occupying the same space at the same time. In like manner we may put it that the super-cube, if presented to us broadside, would look like two cubes occupying the same space at the same time, while in other positions the two cubes would only partially occupy the same part of space.

Now of this we can get some sort of representation by an interesting experiment with the stereoscope. Just as two flat drawings will give a representation of solidity when appropriately drawn and placed in that instrument, so two solids viewed through it will give some sort of idea of the super-solid.

The experiment is striking and remarkable. Place in the centre of the field on each side in a stereoscope a solid cube. On looking through the instrument the two combine, and one cube is apparently seen. Now while looking at this one cube move slightly either of the cubes as it lies in the stereoscope, and it will be seen that our apparent one cube was composed of two occupying the same space at the same time. With the movement of one cube it is seen to pass partly out of the other, and we have an impression as to our super-solid exactly the counterpart of the Flatlander's impression of the cube as shown to him in the perspective drawing, first full face (the two squares occupying the same space and appearing as one) and then a more side view in which the two squares only partially occupy the same space.

Using a cube on one side in the stereoscope and a ball of approximately the same size on the other the effect is still better seen, and without moving either the strange spectacle is revealed of a sphere and a cube occupying together the same part of space.

The experiment affords, of course, but a suggestion of the fourth dimension, yet taken for what it is worth that suggestion is pregnant and of no small interest.

Conducted by F. SHILLINGTON SCALES, F.R.M.S.

Microscopical Material.

By the kindness of Mr. W. S. Rogers, of Upper Warlingham, I was able last month to offer to the microscopical readers of "KNOWLEDGE AND SCIENTIFIC NEWS" some "Comfrey" leaves (*Symphytum officinale*), which show well the beautiful bases of the leaf hairs. Mr. Rogers states that the appearance referred to is not seen in the leaves when fresh or when dried under pressure, but would seem to be brought into prominence by the blackening of the leaves when they lie fermenting on the ground in autumn. He adds that the material is intractable to handle, the dried leaf being brittle and inclined to curl, and he has therefore punched them into ¾ inch circles. They should, of course, be mounted as opaque objects. I regret that by a printer's oversight this notice was omitted last month, whilst the coupon was omitted the month before, thus causing unnecessary trouble to my many correspondents.

Preserving Specimens of Orthoptera.

A recent number of the American *Journal of Applied Microscopy* contains some interesting suggestions for preserving specimens of Orthoptera. As the writer says, their comparatively large size, juicy bodies, when alive or just killed, brittleness of limbs and antennæ when dried, their proneness to fading after death, and their liability to the attacks of mould and museum pests, all seem to conspire against their preservation. The larger and more showy specimens are best known, and the smaller and less brightly coloured forms are either entirely unknown or have come to the notice of the very few specialists who have ventured into an almost forsaken field. There is, therefore, a rich field for investigation for any microscopist who is in want of a fitting direction for his studies.

Placing these insects in alcohol and other liquid preservatives has, in fact, overcome the objection to the soft juicy bodies that so quickly shrivel and become discoloured when treated by the ordinary means of preserving insects; but it has the disadvantage of quickly effacing the many bright colours common to such large numbers of them, and even changes minute structural characteristics, so as to render the insects difficult of recognition. It also adds greatly to the space taken up by the collection, and renders their transportation difficult. Still it is an effective preservative against insect pests, such as *Dermestes*, &c. Orthoptera can, however, be handled "taxidermically"—*i.e.*, stuffed much as birds, &c., are stuffed. Instead of throwing the insects into spirits, they should, when captured, be killed in the cyanide bottle. The specimen being then held in the fingers and thumb of the left hand, with a fine, sharp-pointed pair of scissors open the abdomen by cutting across the middle of the two basal segments on the lower side, then reverse and cut the opening a trifle larger by nearly severing the third segment. Then extract all the insides (intestines, crop, ovaries, &c.), along with the juices, using fine forceps for this purpose, and wipe out the inside with a small wad of cotton. This being done, the insect may be pinned into a box or wrapped in paper and packed away for future use.

The "stuffing" is carried out as follows. Cut some raw cotton into short pieces, and fill up the insect through the opening made as above, using similar fine forceps and taking care not to stretch or distend the abdomen beyond its original dimensions. When the filling is completed draw the edges of the severed segments carefully together, and press the sides of the abdomen into shape with the fingers. This can all be done, after a little practice, in four or five minutes' time. It will be found that the insect will not decay or turn dark, the original colours will be almost entirely preserved, and there is but little danger of attack by museum pests, or of the mould which so frequently spoils objects which are long in drying.

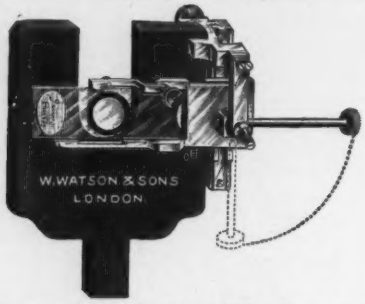
Mouldy specimens can often be saved by being placed in a tin box between wet cloths or blotting papers well sprinkled with dilute carbolic acid, and left for twenty-four hours to thirty-six hours, or until sufficiently soft not to break when handled. Then pour some alcohol into a dish, and add to it about one-twentieth as much liquid carbolic acid. With a camel-hair brush carefully clean the entire insect, taking care to wash every portion with the mixture of alcohol and acid.

In arranging in the cabinet the suggestion is made that much space can be economised by directing long antennæ backwards along the sides of the insect, and by folding and crossing the legs beneath the body. In the Saltatoria, or jumping forms, the pin should be inserted near the back edge of the pronotum, a little to one side of the middle, and directing it to the rear, letting it pass downward through the mesothorax, thereby tightly fastening together the two sections of the body. In the other forms, *Blattoidea*, *Mantoidea*, and *Phasmoidea*, the pin should be inserted behind the pronotum through the middle of the body, taking care to select a solid portion for this purpose, without running the pin through the basal portion of any of the legs.

The "Argus" Attachable Mechanical Stage.

This stage was designed for use with the "Argus" microscope, noticed in the January issue of "KNOWLEDGE," page 21, but it can be fitted to any ordinary microscope, being attached

by means of a thumb screw only. It is decidedly original in design. A friction wheel, actuated by a single milled head, is in contact with a broad brass plate attached to the clips which hold the slide. A steel spring gives the necessary pressure, and the spindle bearing the friction wheel and milled head is movable on a vertical pin. A glance at the illustration will make the principle clear, and it will be seen that the stage



travels readily in a vertical or horizontal direction, or in any intermediate diagonal direction, according to the position in which the milled head is held whilst rotating. Check pins indicate the horizontal and vertical positions respectively. By this means not only are rectangular movements obtained, but any desired diagonal movement is obtained in addition. The whole stage works with great smoothness and sensitiveness. The mechanism is entirely on one side of the stage, so that none of the working parts are in the way of the instrument.

Quekett Microscopical Club.

The 409th ordinary meeting of the Club was held on December 18, at 20, Hanover Square, W., the Vice-President, A. D. Michael, Esq., F.L.S., in the chair. A most interesting collection of diffraction gratings of various kinds was on view, and the exhibitor, Mr. Julius Rheinberg, F.R.M.S., briefly described them and pointed out the curious optical effects obtainable. Among the most interesting of the exhibits was a reflecting diffraction grating on plate glass, silvered on the grating side, ruled by Colonel L. Paxton, of Chichester. It consisted of intersecting systems of circles. Each system consisted of a series of excentric circles, the locus of their centres being an intermediate circle. When exposed horizontally below a flame, an observer stationed a few yards away could see four intersecting rings of light stereoscopically projected several inches in front of the mirror, whilst a similar system of rings was seen several inches behind the mirror.

Mr. Rheinberg then read a paper "On an Overlooked Point concerning the Resolving Power of the Microscope." It dealt with a discovery made from the theoretical standpoint some years ago by Dr. Johnstone Stoney, F.R.S., which had only recently been practically demonstrated—viz., that an objective would resolve and separate two dots or lines of a known distance apart, although unable, owing to its N.A., to resolve a series or band of dots or lines at equal similar intervals. The experiment was practically demonstrated to the Club, a Grayson test plate of 15,000 lines to the inch being used for the purpose, with a Zeiss 8 mm. apochromat, and a 27 mm. compensating ocular.

Mr. D. J. Scourfield, F.R.M.S., then gave an epitome of the third part of his Synopsis of the British Fresh Water Entomostraca. It dealt with the Ostracoda, of which we have about 62 species, nearly all widely distributed; the Phyllopoda, of which there is only a single form now recorded, another form, *Apus cancriformis*, being apparently extinct; and the Branchiura, with two species, one being extremely rare. This was the concluding portion of Mr. Scourfield's valuable series of papers on the British Entomostraca.

The 410th ordinary meeting of the Club was held on January 15, the President, Mr. George Massie, F.L.S., in the chair. There was a large attendance. Mr. C. Rousselet, F.R.M.S., read a paper on "A New Freshwater Polyzoon from Rhodesia," which was illustrated both by a diagram and by specimens shown under the microscope. The polyzoon referred to differs in many ways from all other known species, and is especially characterised by the production of elliptical statoblasts having five spines at each end, the spines being armed with minute hooks.

Mr. J. T. Holder exhibited an interesting series of lantern slides of Foraminifera from photographs taken by himself. The specimens varied much in size, some of the large groups being $\frac{3}{4}$ inch in diameter, and containing several hundred selected specimens from $\frac{1}{100}$ to $\frac{1}{8}$ inch in diameter. A 4-inch objective was used, and in spite of the difference in focal plane the photograph was quite successful. Other photographs were taken with 2-inch and 1-inch objectives. The exposures varied from a few seconds to three quarters of an hour, an isochromatic screen being invariably used. The camera and apparatus employed were also shown on the screen.

Mr. Earland gave a brief description of the slides, and congratulated Mr. Holder on his success, and especially on the way in which the glassy transparency, which was one of the most beautiful features of the hyaline Foraminifera, had been reproduced in the photographs. Attention was particularly drawn to *Frondicularia alata* from Cuba, found at the depth of 700 fathoms. The genus was now almost extinct, but was abundant in Secondary times. At present it was found in numbers in only two small areas in the world, each widely distant from the other, namely, the Caribbean Sea and the shores of New Guinea. Attention was also called to the great difference in the form and structure of the specimens shown on the screen. This was due to the different methods of growth, which, in turn, was a result of the difference in size of the primordial chambers. It was a typical instance of dimorphism, and the two specimens represented the megalospheric and microspheric types respectively. Two especially interesting slides were *Polystomella craticulata* and *Orbulina universa*. In the first the foraminifer was shown side by side with a cast of the animal's body, the cast being quite perfect, and exhibiting every detail of structure, the canal system and primordial chamber being sharply marked on the screen. In the slide of *Orbulina universa* some of the spherical details had been laid open in order to show the internal Globigerina shell. This was shown in various stages, from the perfect shell, attached by five spines to the inner surface of the sphere, and not distinguishable from a pelagic Globigerina, to the last disappearing chamberlet. The mystery of these internal chambers, which were only found in a small percentage of specimens, was unsolved; but a theory had been invented to account for them. It was supposed that the pelagic Globigerina, in order to protect its delicate spinous shell from the action of the waves, formed a spherical shell outside it, and the internal shell being then of no further use was gradually absorbed and disappeared. A number of photographs of rock-sections next exhibited showed Foraminifera *in situ*, and exemplified the important part played by them in the structure of the earth, more important than all other animals put together. They were amongst the very earliest inhabitants of the earth, their remains being found as far back as the Lower Cambrian strata, and some of the genera, perhaps even species, found there were still in existence. They formed enormous masses of limestone in carboniferous times, and the gault and chalk were largely composed of their remains. But they reached their greatest development in Tertiary times, when the famous Nummulitic and Alveolina limestones were built up by them, the deposits stretching in an almost unbroken series across Europe and the western half of Asia, reaching a thickness in places of many thousand feet. Their modern representatives were both small and infrequent.

In addition, a number of marine organisms, admirably preserved, were shown under microscopes on behalf of Mr. H. J. Waddington, a former member of the Club.

ROYAL MICROSCOPICAL SOCIETY, December 16, Dr. Henry Woodward, F.R.S., President, in the chair. Mr. F. W. Watson Baker exhibited under microscopes an exceedingly complete and valuable series of slides, 16 in number, illustrating the development of an ascidian from the fertilization of the ovum to the larval stage. The slides were prepared by a gentleman well known to many of the Fellows, who had been most successful in his management of marine aquaria. Dr. G. J. Hinde read a paper "On the Structure and Affinities of the Genus *Porosphæra*," which was illustrated by diagrams, mounted slides under microscopes, and specimens, many collected by Dr. Hinde in his garden at Croydon, which had

been weathered out of the chalk.—January 20, Annual Meeting the President, Dr. Henry Woodward, F.R.S., in the chair. The Curator, Mr. C. Rousselet, exhibited an old microscope by Plössl, of Vienna, which had been sent on approval. It has a folding tripod foot which carries a short column surmounted by a compass joint for inclining the instrument. To a hinged attachment of the compass joint a triangular steel bar is fixed. On this bar slides a bracket, having a curved arm, to which the body of the microscope is secured. A rack is sunk into the base or back of the triangular bar for the coarse adjustment, the pinion of which is contained in the sliding bracket. The stage, which is also carried by the triangular bar, has slow rectangular movements of very limited extent. There is also a micrometer movement, right and left, for measuring objects, and a fine adjustment for focussing. There are six object glasses which can be used separately or in various combinations of two or three glasses. Among the apparatus is a lenticular prism for illuminating opaque objects and two diaphragms for reducing the diameter of the reflecting surface of the mirror. The ballot for officers and Council for the ensuing year was then taken, and Dr. Dukinfield H. Scott, F.R.S., was elected President. The other business of the annual meeting having been disposed of, Dr. Henry Woodward, the retiring President, proceeded to give his annual address, taking as his subject "The Evolution of Vertebrate Animals in Time." His paper was illustrated by diagrams, drawings, and slides, about 80 in number, shown upon the screen.

A Novel Electric Traction System.

In No. 2 of the *Elektrotechnischer Anzeiger* E. Lenggenhager describes an electric railway traction system which is being developed at the present moment by a Swiss "Studiengesellschaft," appointed for the purpose of finding out an electric railway system suitable for that country, which, on account of her dependency on the foreign coal market, evidently should endeavour to utilize her wealth in hydraulic power. Speeds, on the other hand, are limited there on account of the steep gradients, small curves, and numerous stoppages. The system in question uses *steam locomotives heated by electricity*. Electric heating, as is well known, will work with the highest possible efficiency, so that the total efficiency will mainly depend on the output of the mechanical part of the locomotive, being the steam-engine proper. Any coal steam locomotive could readily be converted into an "electrothermical" locomotive by simply replacing the fire-box and boiling-tube of the boiler by a number of parallel electric heating-walls running throughout the boiler and being composed of two copper or iron sheets. The author suggests using in this connection the well-known Prometheus heating elements. The consumption of current would depend on the consumption of steam. Let the boiler be designed for accommodating 4000 litres of water, which are to be brought within 3 hours from 10° up to about 190° C., corresponding with a steam pressure of 50 kg. per sq. cm. In the case of an efficiency only as high as 90 per cent. the following data would be obtained: 4000 l. of water would require, in order to be brought to the above temperature, 4000 × 180 = 720.000 kg. cal.; 1 kg. cal. = 1·275 eff. watt. hours, therefore 720.000 kg. cal. = about 900 eff. kw. hours, or, distributing this amount over 3 hours = about 300 kw. A consumption of steam of 1000 kg. per hour would accordingly require a supply of current of about 225 kw. As regards the advantages inherent in the electrothermic system, the resistance of the steam accumulator against current shocks should be mentioned. There is the further advantage of both direct and alternating currents being practicable in this connection, any desired combination being suitable. The mean efficiency of electrothermic locomotives, being about the same as that of an electromotive machine of the same size, would be about 60 to 70 per cent., whereas the total efficiency of a railway system, on account of the more advantageous utilization of the load, would be higher for the former. Furthermore, the adoption of electrothermic service may take place gradually, being much easier than that of electromotive service, on account of the lower cost of the conversion and the easiness with which the *personnel* may be trained for the new service. A possible conversion of electrothermic into electromotive railway service would finally be readily made should the electromotive service in future be so improved as to become superior to the electrothermic system.—A.G.

Geodetical Instruments.

From Mr. James Hicks, of Hatton Garden, we have received a catalogue of the new types of hand surveying instruments designed and patented by Sir Howard Grubb, F.R.S. These extremely ingenious and useful instruments were designed by the inventor primarily for the use of those whose work in surveying required simple, portable, and easily comprehensible instruments for rapid work. The principal advantages common to all the instruments are the film surface of the glass, which is of a kind capable both of reflecting and transmitting a considerable portion of the light which falls on it; and the adoption of the collimator system for parallelising rays. By the use of the Reynolds-Grubb film, light from two different directions can be directed into the eye of the observer without recourse to the inconvenient old method which was known as "dividing the pupil." The collimator system of parallelising rays has also great advantages in convenience and simplicity of observation. Among the instruments to which these methods have been specially and advantageously applied are the small clinometer and prismatic compass and a level. Mr. Hicks also comprises in his catalogue of these new types of hand surveying instruments, an optical square fitted for use with the naked eye, an attachment for a telescope, a graphometer, and a pocket surveying instrument.

REVIEWS OF BOOKS.

Who's Who, 7s. 6d. (A. & C. Black), grows stouter every year, and now contains no fewer than 17,000 biographies. Its great usefulness is so well recognised that it need not be dilated upon. Some few of the biographies might, one would think, be curtailed, especially as regards "recreations," one of which, we note, reads "homely table games of cards, chess, backgammon, halma, cribbage, &c." Otherwise, the succinct accounts of the lives of every Englishman of any note are most complete, and just what one requires.

Who's Who Year Book, 1s., is a small book containing the tables which were formerly incorporated in *Who's Who*, but which have been deleted from time to time to make room for the ever-increasing number of biographies. These tables are most useful for reference, including as they do not only such as are to be found in many other annuals, but also lists of Royal Academicians, Bishops, Newspapers and Magazines, Pseudonyms and Pennames, Principal Schools (with number of pupils and cost), Fellows of the Royal Society, Societies, &c., Chairs and Professorships, Heirs of Peers, &c.

The Englishwoman's Year Book, 2s. 6d. (A. & C. Black), "aims at giving some idea of the extent of women's work and interests, and some guidance to those who want to help their fellow-creatures, whether as individuals they live lives of which their own home is the centre, or take a wider view of their opportunities and responsibilities," and has a wonderful mass of useful information packed into its 350 pages.

BOOKS RECEIVED.

(The notice of books in this column does not preclude the review of them at a later date).

Studies in Heterogenesis, by H. Charlton Bastian, M.A., M.D.Lond., F.R.S. (Williams and Norgate, one vol.; price 31s. 6d.) A monumental work, illustrated with more than eight hundred micro-photographs, and summing up the whole number of instances of the apparent transformation of the substances of parent matrices into new forms of life. The author examines the alternative explanations of these phenomena—(1) That the resulting forms of life are due to the invasion and multiplication of parasites within what appear to be parent organisms; (2) that the resulting forms of life are in reality heterogenetic products originating from the very substance of the organisms from which they proceed—and gives his reasons for adopting, after prolonged and careful study, the second of these theorems.

XUM

The Worship of the Dead, by Colonel J. Garnier. (Chapman and Hall, one vol.). Colonel J. Garnier's work on "The Worship of the Dead" (Chapman and Hall) deals with the origin and nature of Pagan idolatry and its bearing upon the early history of Egypt and Babylonia. The voluminous materials collected by previous writers on the subject are here set forth within a moderate compass and in a readable form. The book is profusely illustrated with interesting examples of the statues of ancient gods.

Cassell's Popular Science (Cassell and Co.), edited by Alexander S. Galt, with contributions from T. C. Hepworth, Professor Bonney, Frank Weedon, John Fraser, F.L.S., Wilfred Mark Webb, F.L.S., Dr. Andrew Wilson, Dr. Bernard Hollander, and William Ackroyd, F.I.C. The subjects range from radium to carnivorous plants, and from the transit of Venus of 1882 to the working dynamo. The articles, of which there are some sixty, are clearly and well written, and in every respect justify the title under which they are collected.

British Tyroglyphidæ, by Albert D. Michael, F.L.S., F.S.S., &c. Vol. II. (Printed for the Royal Society.) This volume contains the description, with plates, of the genera and species of the British Tyroglyphidæ, from the genus Chortoglyphus to the Tyroglyphus Wasmanni. A list of foreign species is added.

The Old Testament and Historical Records, by Theophilus Pinches, LL.D. (One vol. Second Edition. S.P.C.K.) In the second edition of the "Old Testament in the Light of the Historical Records and Legends of Assyria and Babylonia," Dr. Pinches adds some exceedingly valuable and interesting matter on the Laws of Hammurak, together with a translation of the laws and notes on Delitzch's lectures on this subject.

A School Geometry. Parts I.-V. By H. S. Hall, M.A., and F. H. Stevens, M.A. (Macmillan. One vol.; price 4s. 6d.)—This is a publication, in one volume, of a geometry for schools based on the recommendation of the Mathematical Association and on the new Cambridge syllabus.

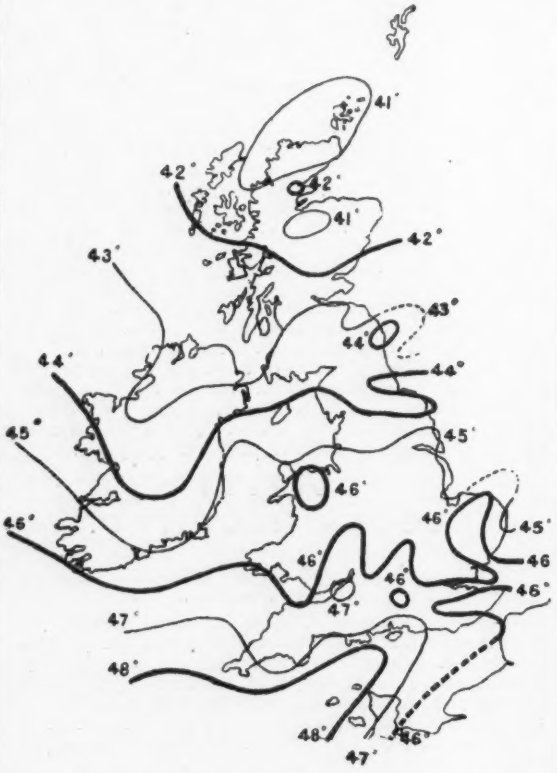
Descriptive Chemistry, by Lyman C. Newell, Ph.D. One vol., with supplementary vol. of experiments. (London: D. C. Heath; price 4s. 6d. and 1s. 6d.)—Intended for teachers who wish to emphasise the facts, laws, theories, and applications of chemistry. The experiments have been prepared for limited laboratory facilities.

Chess Problems.

OWING to the great amount of matter which we have on hand we have felt it necessary to again postpone publishing the Chess Problems. We should be very glad to have the opinions of those interested in this subject as to the continuance or otherwise of the Chess Column.

LAST YEAR'S WEATHER—MARCH, 1903.

DISTRIBUTION OF MEAN TEMPERATURE.



The general distribution all over our islands agreed very fairly with the normal, but the actual values were above the average in all localities excepting the west and north of Ireland.

RAINFALL.

Rainfall was considerably in excess of the average over the country generally, but was rather deficient on the east coasts of England and the north-east coasts of Scotland. Over the western half of the Kingdom the excess was very large, the amount at many stations being more than double the average.